THE BREEDING ECOLOGY OF A DECLINING FARMLAND BIRD: THE TURTLE DOVE *Streptopelia turtur*

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Dedication

To my parents,
for all their support

Her vine, the merry cheerer of the heart,
Unpruned dies; her hedges even-plashed,
Like prisoners wildly overgrown with hair,
Put forth disordered twigs; her fallow leas
The darnel, hemlock and rank fumitory
Doth root upon, while that the coulter rusts
That should deracinate such savagery;

William Shakespeare - Henry V, Act 5, Scene 2

ABSTRACT

STEPHEN J. BROWNE **2002**

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The Turtle Dove is a migrant to Britain, being present only during its breeding season. In recent years the species has undergone a 69% decline in population size and a 25% contraction in breeding range in Britain. Since the early 1960s, very little work had been carried out on the species in this country.

This study uses a variety of data sources to investigate the breeding ecology of the species and compares the results with those collected in the 1960s.

Territories were established in areas with scrub, hedges and woodland with these habitats being used for nesting. The comparison of data showed that Turtle Doves today have a shorter breeding season and produce about half the number of clutches and young per pair than formerly. This would lead to a population decline of 17% *per annum*. No aspect of breeding ecology or success altered significantly for individual nesting attempts during 1940 to 2000. A shift in the timing of autumn migration supports the theory that Turtle Dove are undertaking fewer nesting attempts.

A change in the species foraging ecology resulted in a switch in the diet from predominately weed seeds in the 1960s to cultivated seeds today. Experimental supplementary feeding did not lead to a detectable change in territory density, territory size or breeding success.

In recent years the availability of suitable Turtle Dove nesting habitat, has been greatly reduced in the farmed environment, and that which remains is less suitable. The lack of suitable nesting habitat may preclude or limit the numbers of Turtle Doves breeding in certain areas of its British breeding range. Reduced food availability, both spatially and temporally, may make birds more likely to cease breeding earlier than during the 1960s and to reduce their number of nesting attempts.

This study suggests that the recovery of Turtle Doves in Britain is dependent upon the provision and sympathetic management of nesting and foraging habitats.

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AUTHOR DECLARATIONS

1. During the period of registered study in which this thesis was prepared the author has not been registered for any other academic award or qualification.

2. The material included in this thesis has not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

Stephen J. Browne

12 May, 2002

Conventions and acronyms

Common or vernacular names are used throughout this thesis with the scientific names being given in Appendix 1. Only common names are used for crops. Common names are capitalised, but higher taxa are not.

The common and scientific names of birds follow Voous (1973-77), mammals follow Corbet & Southern (1991) and plants follow Stace (1991).

The acronyms used:

AAP	Arable Area Payments
AD_{50}	Arrival $Date_{50}$
ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
BAP	Biodiversity Action Plan
BBS	Breeding Bird Survey
BST	British Summer Time
BTO	The British Trust for Ornithology
CAP	Common Agricultural Policy
CBC	Common Birds Census
CSL	Central Science Laboratory
DD50	Departure $Date_{50}$

DSR	Daily Survival Rate
EEC	European Economic Community
ESA	Environmentally Sensitive Areas
FAD	First Arrival Date
FED	First Egg Date
GCT	The Game Conservancy Trust
GIS	Geographical Information System
MAFF	Ministry of Agriculture, Fisheries and Food (now DEFRA Department of the Environment, Food and Rural Affairs.
MANOVA	Multivariate analysis of variance
MCO	Minimum Convex Polygon
NRC	Nest Record Card
NRS	Nest Record Card Scheme
s.e.	Standard error
SPEC	Species of European Conservation Concern
WWF-UK	Worldwide Fund for Nature

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CHAPTER 1

INTRODUCTION

In recent decades the abundance and range of a number of taxonomic groups found on farmland has declined. Although these declines have been most apparent and most widely reported amongst birds (e.g. Fuller *et al.* 1995, Siriwardena *et al.* 1998, Chamberlain *et al.* 2000) other groups such as mammals (Milton 1994), invertebrates (Donald 1998) and plants (Sotherton & Self 2000) have also been affected. Of 40 species of birds thought to be dependent on farmland, 11 (27%) have suffered population declines of over 50% during the period 1968 to 1998 (Baillie *et al.* 2001; Table 1.1). Of these bird species the Turtle Dove is one of the most seriously affected, having declined by 69% during 1968 to 1998 (Baillie *et al.* 2001).

With such a wide range of flora and fauna involved, a number of likely hypotheses have been proposed to explain the population declines. However, one feature that all affected species have in common is that they inhabit farmland, which is known to have changed dramatically over the last 40 years through agricultural intensification (e.g. O'Connor & Shrubb 1986, Fuller *et al.* 1995, Brickle *et al.* 2000).

Table 1.1 Population trends (1968-98) (Baillie *et al.* 2001), range trends (1968-1991) (Gibbons *et al.* 1993 and the European status (Heath *et al.* 2000) of 40 farmland bird species (Campbell *et al.* 1997). Farmland specialist species are those that are solely dependant on the open-field part of farmland. Species are ordered by population trend and species with declining population or range (>10%) are shown in bold. n.s. indicates species that are not surveyed.

Species	Farmland specialist	Population trend	Range trend in UK	European status
Tree Sparrow		-95	-20	Secure
Grey Partridge	*	-83	-19	Vulnerable
Corn Bunting	*	-83	-32	Secure
Spotted Flycatcher		-79	-25	Declining
Starling		-70	-4	Secure
Turtle Dove		-69	-25	Declining
Song Thrush		-60	-2	Secure
Linnet		-59	-5	Secure
Yellowhammer		-54	-7	Secure
Skylark	*	-53	-2	Vulnerable
Bullfinch		-50	-7	Secure
Reed Bunting		-49	-12	Secure
Dunnock		-46	-3	Secure
Mistle Thrush		-43	-2	Secure
House Sparrow		-42	-5	Secure
Yellow Wagtail	*	-40	-9	Secure
Lapwing	*	-34	-9	Secure
Meadow Pipit	*	-34	-3	Secure
Little Owl		-29	-11	Declining
Red-legged Partridge	*	-28	32	Vulnerable
Blackbird		-26	-2	Secure
Greenfinch		4	-3	Secure
Goldfinch		9	-5	Secure
House Martin		12	-1	Secure
Swallow		21	1	Declining
Chaffinch		21	1	Secure
Robin		23	1	Secure
Pheasant		38	1	Secure
Wren		50	0	Secure
Pied Wagtail		70	0	Secure
Woodpigeon		86	-2	Secure
Stock Dove		157	-7	Secure
Collared Dove		1284	7	Secure
Cirl Bunting		n.s.	-83	Secure
Red-backed Shrike		n.s.	-83	Declining
Stone Curlew	*	n.s.	-42	Vulnerable
Barn Owl		n.s.	-38	Declining
Sand Martin		n.s.	-24	Declining
Quail	*	n.s.	99	Vulnerable
Hobby		n.s.	141	Secure

1.1 The history of agricultural intensification in Britain

Before tree clearance during the Neolithic period, extensive areas of forest cover and low-lying marshland dominated the British landscape (Rackham 1990). Tree clearance around small Neolithic settlements established the first areas of farmland and as farming developed extensive forest clearance was undertaken until forest cover was reduced to the present day level at around the time of the Norman Conquest (O'Connor & Shrubb 1986).

Throughout the Middle Ages farming was based around an open-field system in which villages farmed 5-6 blocks of land, some of which were used for grazing, growing winter-feed (hay) and growing arable crops (Rackham 1986). The crops were grown on the blocks of land in either two (winter corn followed by fallow) or three (winter corn followed by spring corn followed by fallow) year rotations with stock being grazed in the fallow years. Manuring by stock improved soil fertility, which in turn increased cereal yield. The excess cereal was fed to the stock, which allowed stocking density to increase. At this time stock was maintained by cowherds and shepherds and stock-proof enclosures were not required (Grigg 1989).

Towards the end of the medieval period extensive enclosure of farmland and conversion of arable land to pasture occurred as increasing wool prices made it more profitable and desirable to keep sheep. The British countryside changed markedly as an extensive system of hedges, ditches and fences enclosed farmland into a pattern that is similar to that found today (Pollard *et al.* 1974). Extensive areas of root crops were also grown at that time to feed the stock during the winter. As the network of hedges became established, ditches were dug alongside many of them to improve land drainage. These pasture-dominated areas were concentrated in the West of Britain and the Midlands of England (Rackham 1986, Grigg 1989, Stoate 1995, 1996).

On the lighter soils of the southern and particularly the eastern counties of England arable farming developed into the classic four-course rotation. Under this system a combination of cereal, root and ley crops were grown to improve soil fertility and reduce the plant disease. In addition to increasing crop yield this system also increased the manpower required to cultivate and till the land (O'Connor & Shrubb 1986, Grigg 1989, Stoate 1995, 1996).

Until the start of the nineteenth century agricultural intensification was concerned mainly with the enclosure and drainage of land, the use of natural processes to improve soil fertility and control diseases, and the establishment of regions that were predominately arable or stock rearing areas. However, from the start of the nineteenth century the use of artificial fertilisers began and this allowed farmers to move away from the constraints of the traditional crop rotation system. These early fertilisers included guano, slag and superphosphate (dissolved bones) and were used to improve soil fertility (Wright 1906). The use of pesticides also began at this time, with copper sulphate being used as a seed dressing for cereals, a fungicide and as a basic herbicide. Although basic and limited in use, the perceived benefits of these early agro-chemicals undoubtedly demonstrated the potential value of artificial fertilisers and pesticides to farmers and lead to their further development (Mellanby 1981, Stoate 1995, 1996).

With the development of the crop rotations, the use of the early fertilisers and the increased demand for cereals during the eighteenth and nineteenth centuries, the area of arable land increased to approximately 7.2 million hectares, about 20% of the total land area in Britain (O'Connor & Shrubb 1986). However, by the end of the nineteenth century cheap imports of wheat from America reduced the price of cereals. This culminated in a period of agricultural depression and a consequent reduction in the area of arable land to approximately 5 million hectares in 1930-32 as it was allowed to convert to rough pasture (O'Connor & Shrubb 1986).

The agricultural depression of the 1930s saw the beginnings of an agricultural industry that was supported by government intervention, which sought to ensure that there were unlimited supplies of cheap food. Initially government support was concerned with the dairy industry, but support for the arable sector soon followed. A number of Acts of Parliament were passed during the 1930s that provided payments and subsidies to supplement income, to maintain production, to encourage the use of slag as a fertiliser, and to improve drainage. With the start of the Second World War in 1939, the nature of British agriculture was to change forever (Stoate 1995, 1996). The agricultural depression of the 1930s caused large areas of arable land to be abandoned or converted to pasture and Britain was dependent on cheap import of food, particularly cereals. The U-boat blockages of the North Atlantic during the Second World War prevented much of this food from reaching Britain and given the depressed nature of agriculture at home, food was in short supply and rationing resulted. In response to this farmers were encouraged to improve food production, so that Britain was once again self-sufficient. To encourage this the 1947 Agriculture Act was passed to guarantee prices for agricultural products. With this support agriculture continued to develop and the area of arable land increased substantially. In 1973 when Britain became part of the European Economic Community (EEC) the Common Agricultural Policy (CAP) increased the level of subsidy for agricultural products and limited imports by imposing import duties for goods generated outside the EEC (Pain & Pienkowski 1997, Bignal 1999). With this degree of protection, British agriculture continued to develop. Farming developed into a fully-fledged industry where it became important to reduce costs and maximise profits (O'Connor & Shrubb 1986, Stoate 1995, 1996).

Agricultural subsidies (known as Arable Area Payments, AAP) resulting from the CAP paid farmers for the goods they produced. So the more a farmer produced the more subsidy he received. These subsidies became the driving force behind agricultural intensification during the last 30 years of the twentieth century (Pain & Pienkowski 1997). It was estimated that by the late 1990s subsides accounted for approximate 50% of the EUs agricultural turnover (Buckwell *et al.* 1995). Agricultural intensification heralded considerable changes in the management of grassland. Plant breeding produced high yielding crop varieties and the development of pesticides and fertilisers further increased crop yields. The use of pesticides removed the necessity for crop rotations and farms became either arable of livestock enterprises. The mechanisation of farming increased and consequently the work force required to work on the land reduced (O'Connor & Shrubb 1986, Grigg 1989, Stoate 1995, 1996).

After three decades of support and guaranteed prices the CAP subsidy system encouraged farmers to overproduce. These overproduced products resulted in the notorious "mountains" of food that received a lot of bad publicity. In response the set-aside scheme, by which farmers receive payments for taking land out of production, was established. Towards the end of the twentieth it became apparent that agricultural intensification had had a detriment effect of the environment. This led a number of agri-environmental schemes being established whereby farmers were rewarded for conservation and not just food production (Pain & Pienkowski 1997). The support given to European farmers is regarded by many as out-dated and inappropriate for a modern-day industry and consequently reform of the CAP is scheduled for 2006 (Pain & Pienkowski 1997, Bignal 1999).

1.2 Birds and agriculture

As the British countryside changed over the last 5000 years from predominantly woodland to the modern agricultural landscape that is found today, the avifauna that inhabited it would have also changed. The birdlife of Neolithic Britain would have been dominated by woodland species. These species would have adapted to the changing countryside and made use of increasing woodland edge, smaller woodland blocks, and more recently, hedgerows and hedgerow trees. However, as larger tracks of land became devoid of trees, specialist open field or steppe bird species would have colonised these areas. Consequently it is estimated that about 80% of bird species recorded as farmland birds today are actually woodland species, with only about 7-14% being true open country species (Williamson 1967). Therefore the majority of farmland birds are woodland species that have adapted to using trees within a farmland landscape and very few are actually true farmland birds (O'Connor & Shrubb 1986, Fuller 1995).

There are many definitions and categorisations of farmland bird species in Britain (Williamson 1967, Moore 1980, Fuller *et al.* 1995, Chamberlain *et al.* 2000). One of the most comprehensive groupings is provided by Campbell *et al.* (1997) (Table 1.1) which includes 40 bird species that are found predominately within farmland habitats (one additional species that should have been included is the Corncrake). Of these 40 species only 9 (22%) are open field species. These open-field species spend all year within the arable part of farmland and use the fields for all aspects of their ecology. In fact many avoid the non-farmed habitats and their breeding density may be higher in the more open habitats (e.g. Skylark (Wilson *et al.* 1997) and Lapwing (Wilson *et al.* 2001)).

The other species use the farmed habitats for some aspect of their life cycle but at varying levels. Some species will exclusively use the non-farmed habitats for nesting and the arable areas for feeding (e.g. Turtle Dove (Murton *et al.* 1964, Murton 1968)). Others will nest and feed in the non-farmed habitats during the breeding season, but use the farmed areas for feeding in the winter (e.g. Chaffinch (Whittingham *et al.* 2001)). Others will predominately use the non-farmed areas and only use the farmed areas as a substitute for woodland edge (e.g. Blackbird (Hatchwell *et al.* 1996)).

1.3 Farmland bird declines

Throughout the period of agricultural intensification leading up to the nineteenth century there would have been fluctuations in the abundance and distribution farmland birds in Britain, but on a small scale (Holloway 1997). However, it was not until the early nineteenth century that naturalists of the day started to record the first declines in farmland birds. Early examples of farmland birds that underwent population declines are the Great Bustard and the Stone Curlew (Holloway 1997). These species were open field specialists that occurred in low numbers and declined in direct response to the enclosure of farmland. Another farmland bird species that declined during the nineteenth century was the Skylark, but this decline was due principally to the capture of vast numbers as cage birds and food (Holloway 1997).

It was not until the 1950s and 1960s that the first real alarm bells about the effect of agricultural intensification on wildlife were sounded. Carson (1963) drew the worlds attention to the possibility of "a silent spring" brought about by the direct poisoning of birds by organochlorine pesticides (see also Moore 1962, 1965, 1967). These concerns lead to the banning of many of these chemicals.

In 1968 Peal performed a retrospective analysis of Wryneck numbers in Britain during the period 1939 to 1966 and associated their decline with the reversion of grassland to arable regimes (Peal 1968). In the 1970s the first studies linking the effects of agricultural intensification (e.g. hedgerow removal) with changes to bird-life were undertaken (Murton & Westwood 1974, Bull *et al.* 1976). The first major works linking agricultural intensification and farmland bird declines was presented by O'Connor & Shrubb (1986) and Potts (1986) but it was not until the 1990s when Marchant *et al.* (1990) presented population trends for British breeding birds that the full extent of the problem was realised. Further work by Gibbons *et al.* (1993) and Fuller *et al.* (1995) put the extent of farmland bird declines into perspective and it became apparent that understanding the causes of these declining became the great challenge facing British conservation (Krebs *et al.* 1999). This has resulted in a number of studies of bird population trends, autecological studies of declining species and studies relating bird declines and agricultural intensification being carried out over the last ten years.

The latest information on farmland bird declines (Baillie *et al.*2001; Table 1.1) indicate that 21 (66%) of the 32 species of farmland birds for which there are accurate measures of population size have declined in abundance. Of these 21 species 11 (52%) have declined by over 50% during the period 1968 to 1998. Additionally 22 (75%) of the 32 farmland bird species have had contractions in range size (Gibbons *et al.* 1993; Table 1.1). The declines experienced by farmland birds in Britain have also occurred in bird populations across much of Europe (Heath *et al.* 2000, Donald *et al.* 2001a).

1.4 Mechanisms behind farmland bird declines

A number of studies have shown that the declines experienced by Britain's farmland birds are directly attributable to agricultural intensification (e.g. Potts 1986, Fuller *et al.* 1995, Fuller 2000, Chamberlain *et al.* 2001). The mechanisms involved are outlined here.

The removal and management of non-farmed habitats

The non-farmed habitats of farmland, such as hedges, woodland, scrub, streams, ditches and farm ponds have reduced in area or length throughout the period of agricultural intensification (O'Connor & Shrubb 1986). The increased mechanisation of farming practices has been the main cause for the loss of many of these features. Large farm machinery work most efficiently in large cropped areas and to maximise the initial investment in machinery it was necessary to remove hedges. As machines replaced horses and livestock were no longer kept, farm ponds were no longer required to provide drinking water. To maximise the area of land under crops many of the non-cropped habitats were removed. Additionally, as the use of machinery increased and the work-force on the farm decreased and became more expensive, many of the traditional methods of managing habitats (such as hedge cutting and ditch clearing) were performed by machines and were less sympathetic for wildlife (O'Connor & Shrubb 1986).

Birds predominately use the non-farmed habitats for nesting and feeding so their removal has reduced nesting and feeding habitat availability (e.g. Stoate & Szczur 1994). Modern day management of the non-farmed habitats has reduced their suitability; for example, it has been shown that hedgerow structure dictates which birds use it (Green *et al.* 1994).

Crop management

One of the consequences of agricultural intensification has been the switch from spring sown to autumn sown cereals. This has resulted in the loss of over-winter stubbles, increased height of cereal plants during the breeding season and the earlier harvest of cereals in the autumn. Many gramniverous species of farmland birds fed on the spilt grain within stubbles immediately after harvest and later in the winter they fed on the seeds of weeds that grew in the stubbles (e.g. Cirl Bunting, Evans & Smith 1994). In the spring the growing cereals were important nesting areas for species such as Lapwing and Skylark. However, the taller autumn sown cereals are less favourable and are not used today (Wilson *et al.* 1997, Wilson *et al.* 2001). The earlier harvesting of cereals may also have caused the abandonment of Corn Bunting nests (Stoate 1996).

Grassland management

Before agricultural intensification, grassland formed part of the four-course rotation and this was either grazed or cut annually for hay (O'Connor & Shrubb 1986). Changes in grassland management included a switch from hay to silage, an increased use of herbicide and fertiliser, and increased stocking density. The switch to silage was accompanied by the development of high yielding grass varieties, predominantly Rye Grass which were sown on the ley grasslands. This combined with the use of fertiliser and herbicides reduced species-richness and encouraged rapid growth of the grass, allowing two or three cuts per year. On the permanent pasture improvements to drainage, use of herbicides and fertilisers, and the increased stocking density reduced species rich and structure of the grasslands (Vickery *et al.* 2001).

The grasslands were used by birds as nesting and chick rearing (e.g Lapwing (Galbraith 1988) and Corncrake (Green & Stowe 1993)) and feeding habitats (e.g. Turtle Dove (Murton *et al.* 1964)). The increased cutting of the grasslands destroyed nests and killed adults and chicks (Green & Stowe 1993) and exposed nests to increased risk of predation (Stoate 1996). The reduced species-richness of the grasslands reduced food availability.

Increased pesticide use

Before agricultural intensification, soil fertility was improved and disease was controlled by crop rotation (Stoate 1996). With the introduction of the widespread use of pesticides it was no longer necessary to use the rotations, which reduced crop diversity (see later). Unlike in the early days when the problems associated with pesticides arose from direct poisoning (Sotherton 1991, Burns 2000) it is the indirect effects that are of more consequence today (Campbell *et al.* 1997, Burns 2000). The use of pesticides associated agricultural intensification has reduced food availability for a wide range of bird species (Campbell *et al.* 1997). Pesticides have reduced both the abundance and diversity of invertebrates (the main chick food for many bird species) (Aebischer 1990) and plants, the seeds of which are eaten by many bird species (Campbell *et al.* 1997).

Reduced crop diversity

The absence of the four-course rotation and the polarisation of farms into solely arable or livestock enterprises have reduced crop diversity on farms. This has reduced the nesting and feeding options available to a variety of bird species (e.g. Shrubb & Lack 1991, Chamberlain & Fuller 2000).

1.5 Alternative causes of farmland bird declines

Predation

Fuller *et al.* (1995) suggests that increased predation pressure needs to be considered as a possible explanation for the declines experienced by farmland bird populations. Some bird species (e.g. Magpie and Jay) are known to be major predators of passerine eggs and chicks (e.g. Groom 1983, Møller 1988) and a number of studies have investigated the effect of predation on bird populations. The results obtained from these suggest that predation can affect the populations of some groups of bird, for example gamebirds (Tapper *et al.* 1996, Redpath & Thirgood 1997) whilst other studies show that other groups of birds (e.g. songbirds) appear to be unaffected (Newton *et al.* 1997, Thompson *et al.* 1998). Although the impact of predation at the population level remains unclear, it is known that a number of avian predators have increased over the last few decades (Gregory & Marchant 1996) and it is likely that avian predators may affect breeding bird populations at the local level (Suhonen *et al.* 1994, Stoate & Thompson 2000).

Disease

Although put forward by Fuller *et al.* (1995) as something that needs to be considered, it is unlikely that disease has had a major impact of farmland bird populations. As Fuller *et al.* (1995) suggest it is unlikely that disease would affect only farmland birds whilst woodland birds remain unaffected.

Weather

Severe winter weather both in the UK or on the wintering grounds in Africa have been shown to affect the populations of some bird species found in Britain (Winstanley *et al.* 1974, Furness & Greenwood 1993). However, in most cases the effect is short lived and population recovery is apparent in the following years (Marchant *et al.* 1990), whereas the population decreases experienced by most farmland birds have occurred over a 10 to 20 year period, with an annual decreasing trend over a number of years. It is unlikely that weather has caused farmland bird declines as the observed population trends would be apparent across all habitats (Fuller *et al.* 1995)

1.6 The Turtle Dove

The Turtle Dove is a small (26-28cm) slim member of the Columbidae (pigeon and dove family), weighing approximately 130-180 g, with a thin neck, protruding round head and deep chest giving it a pigeon-like form, but with a rather long wedge-tipped tail and swept-back wings (Cramp 1985, Goodwin 1983). The plumage is blue-grey on the body and head, and white on the belly and undertail coverts. An obvious patch of black and white stripes is present on each side of the neck. The tail is dark grey/black with a distinctive white terminal band. The upper wing coverts are a rich chestnut with central black diamond spots (Cramp 1985). The legs and skin round the eye are red/purple. The different sexes and races are similar but slight plumage and size differences exist (Browne & Aebischer 2000).

There are four races of Turtle Doves in the Western Palearctic. The nominate race *S. t .turtur* is found throughout much of Europe and west Asia. *S. t. arenicola* occurs across North Africa (including the Balearics) and into the Middle East. The other two races are geographically much more restricted, with *S. t. hoggara* being present in the Central Sahara mountains and *S. t. rufescens* in Egypt and Northern Sudan

(Cramp 1985).

Both *S. t. turtur* and *S. t. arenicola* are true migrants, spending the winter period (late October to late March) mostly in the Sahel region of Africa, south of the Sahara in a broad band spanning the continent roughly between 10^{o}N and 20^{o}N. The other two races are thought to be sedentary or undertake only small migratory movements (Cramp 1985).

In the breeding season (early May to mid-August) the range of the European race *S. t. turtur* extends from the Mediterranean to all but the most northern areas of Europe. The European breeding population is estimated to number between approximately 2,800,000 to 14,000,000 breeding pairs (Heath *et al.* 2000). The last census carried out during the period 1988-1991 estimates the British breeding population at 75,000 pairs (Gibbons *et al.* 1993). The British population lies at the north-western edge of the species' breeding range. In Britain it is a lowland bird favouring warm, dry conditions, avoiding the higher ground and rainfall of the west and north (Gibbons *et al.* 1993). This south-easterly bias in distribution concentrates the species into the most intensively farmed, and now predominantly arable, area of Britain. In Europe, the Turtle Dove requires a mixture of hedgerows, shrubby woodland margins or bushy shrubs for nesting and open weedy patches for feeding. Its food comprises mainly seeds of weeds and cereals (Cramp 1985, Gibbons *et al.* 1993). It feeds mostly on the ground, and apparently not often from trees or hedges (Murton *et al.* 1964, Marchant *et al.* 1990).

Further information on the Turtle Dove is given by Goodwin (1983), Cramp (1985) and Rouxel (2000). The European race *S. t. turtur* forms the basis of this study and all future references to Turtle Doves refer to that race, unless explicitly stated otherwise.

1.7 The decline of the Turtle Dove

Survey and census work organised by the British Trust for Ornithology (BTO) suggest a 69% decline in abundance in the UK between 1968 and 1998 (Figure 1.1) (Baillie *et al.* 2001) and a 25% contraction in range between the periods 1968-1972 and 1988-1991 (Gibbons *et al.* 1993). The recent marked reduction that commenced in 1979 followed a lengthy period of apparent increase and range expansion from at least the mid-19th century (Spencer 1965, Duckworth 1992, Holloway 1997). Some local declines were apparent from the 1950s (Goodwin 1989) but trends from census work suggest that the general increase continued up to 1978/79 (Marchant *et al.* 1990). A few local studies showed Turtle Dove abundance to vary in a manner similar to the national trend (Hongell & Saari 1983, Miller 1992). These declines have been so severe that the majority of the UK population is now restricted to the most southern and eastern counties of England and, by extrapolation from the 1988-91 census and subsequent decline rates, probably numbers only about 30,000 pairs in 2001. The decline is of such concern that the UK government has placed the Turtle Dove on the list of priority species considered by the UK Biodiversity Action Plan (BAP). One of the recommendations of the UK Species Action Plan for the Turtle

Dove is to undertake an autecological research project to identify the cause of the recent decline, in order to form a recovery plan.

The pattern of range expansion followed by a recent decline has been repeated elsewhere in Europe, the start of declines being noted from the 1950s onwards (Holzwarth 1971, Kraus *et al.* 1972, Cederwell 1978, Hongell & Saari 1983, Bijlsma 1985, Yeatman-Berthelot & Jarry 1995). Although migratory data are often rudimentary or non-existent, it is believed that the decline of the Turtle Dove occurred from the mid-1980s onwards, and particularly in the countries of western Europe (Tucker & Heath 1994, Heath *et al.* 2000). The observed declines across European countries have made Turtle Doves a Category 3 species of European conservation concern (SPECs), which is a "species whose global populations are not concentrated in Europe, but have an Unfavourable Conservation Status in Europe" (Heath *et al.* 2000).

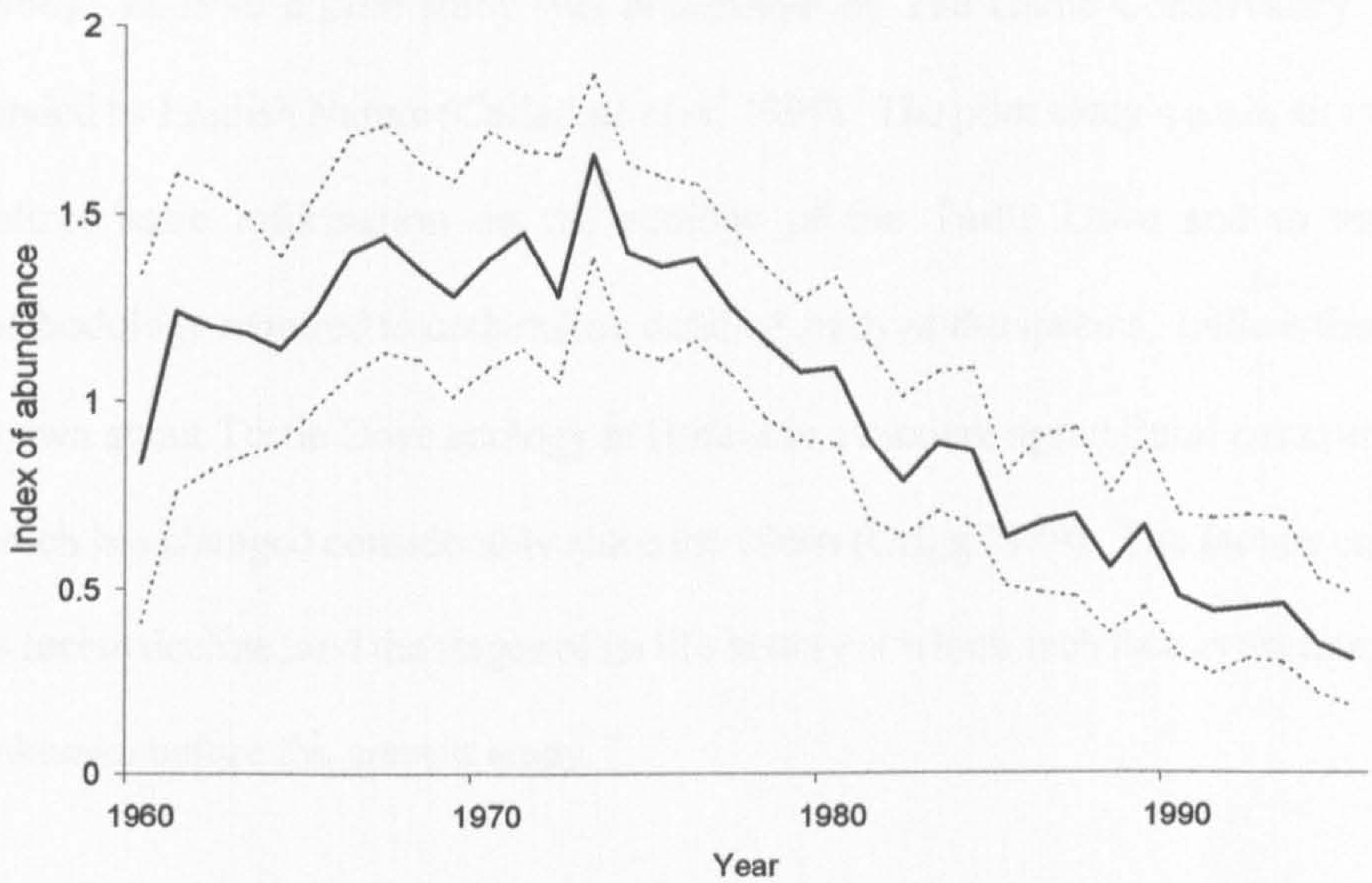


Figure 1.1 Index of abundance of the Turtle Dove in Britain from 1963 to 1998, from the BTO CBC data (Baillie *et al.* 2001) The index (the solid line) was calculated using the Mountford method and the 95% confidence limits (dotted line) were generated by bootstrapping (Peach & Baillie 1994).

There are potentially three stages in which factors could have affected Turtle Doves and caused the observed decline in abundance and range contraction: on the wintering grounds, on migration or during the breeding season. This study concentrates on the factors potentially affecting the species during the breeding season in Britain.

1.8 Previous research on the Turtle Dove

The Turtle Dove has been surprisingly little studied in Britain. Until recently the only major ecological study was completed in the 1960s (Murton *et al.* 1964, Murton

1968). In 1996 a pilot study was undertaken by The Game Conservancy Trust, funded by English Nature (Calladine *et al.* 1997). The pilot study's main aim was to collect basic information on the ecology of the Turtle Dove and to test the methodology required to undertake a detailed study of the species. Little is therefore known about Turtle Dove ecology in Britain in a modern agricultural environment, which has changed considerably since the 1960s (Grigg 1989). The factors causing its recent decline, and the stages of its life history at which such factors operate, were unknown before the present study.

Turtle doves have been studied throughout their European breeding range. The breeding biology of the species has been investigated in Bulgaria (Nankinov 1994a, Nankinov 1994b), Czechoslovakia (Pikula & Beklova 1984), France (Genard 1989), Germany (Holzwarth 1971, Kraus *et al.* 1972), Portugal (Dias & Fontoura 1996, Dias *et al.* 1996), Southern Urals (Kotov 1974), Spain (Peiró 1990), Sweden (Cederwell 1978) and The Netherlands (Bijlsma 1985). Other studies have looked at specific aspects of Turtle Dove biology including diet (Garzón 1974, Kiss *et al.* 1978, Jimenez *et al.* 1992, Dias & Fontoura 1996) and habitat requirements (Aubineau & Boutin 1998). Turtle dove migration has received a lot of attention (eg: Ash 1956, Bourne & Beaman 1980, Genard 1989, Marchant 1969, Mountfort 1981, Nankinov 1994b, Rappe 1965) as has the biology of the species on its wintering grounds in Africa (Morel & Morel 1979, Morel 1985, Morel 1987). The results of these studies are discussed in the relevant chapters of this thesis and are compared with those collected by this study.

1.9 Aims of the study

The aims of this study are to:

(1) To investigate the feeding ecology, breeding ecology and habitat use of Turtle Doves on arable farmland in the UK, including the role of herbicides in affecting food resources;

(2) To manipulate food resources experimentally in order to assess their importance in determining Turtle Dove density, home-range size, breeding success and return rate;

(3) Analyse Turtle Dove data from long-term BTO Common Birds Census plots in order to associate temporal trends in breeding density with changes in land use and to present a national picture of the species' habitat requirements.

(4) Analyse data from BTO Turtle Dove Nest Record Cards in order to examine national trends in breeding success.

(5) Collate data on arrival and departure dates of Turtle Doves at UK coastal bird observatories to test whether changes in the timing of breeding may be caused by changes in the timing of migration.

(6) Collate Turtle Dove biometric data from UK bird ringers and observatory records to test whether body condition has declined through time.

(7) To compare the above findings with the results of pre-intensification work in the UK, and produce recommendations for reversing the decline of the Turtle Dove population through conservation actions within the UK.

CHAPTER 2

STUDY SITES & GENERAL METHODS

2.1 Study sites

Two contrasting sites were used for the intensive part of this study, which took place in 1998-2000. These were at Ixworth Thorpe, north-west Suffolk, and at Deeping St Nicholas, south Lincolnshire (Figure 2.1). They were the same two sites studied during the pilot study in 1996 (Calladine *et al.* 1997). Ten further sites within East Anglia were used for the experimental component of the study in 1999-2000 (Figure 2.1). The exact start and finish dates for fieldwork undertaken during 1998-2000 are given in Table 2.1.

Table 2.1 Start and finish dates of fieldwork carried during this study

Study Site	1998		1999		2000	
	Start	Finish	Start	Finish	Start	Finish
Ixworth Thorpe	24/4	02/9	26/4	27/8	22/4	25/8
Deeping St Nicholas	15/5	17/8	28/4	27/8	24/5	25/8
Experimental sites	n/a	n/a	2/5	16/8	30/4	14/8

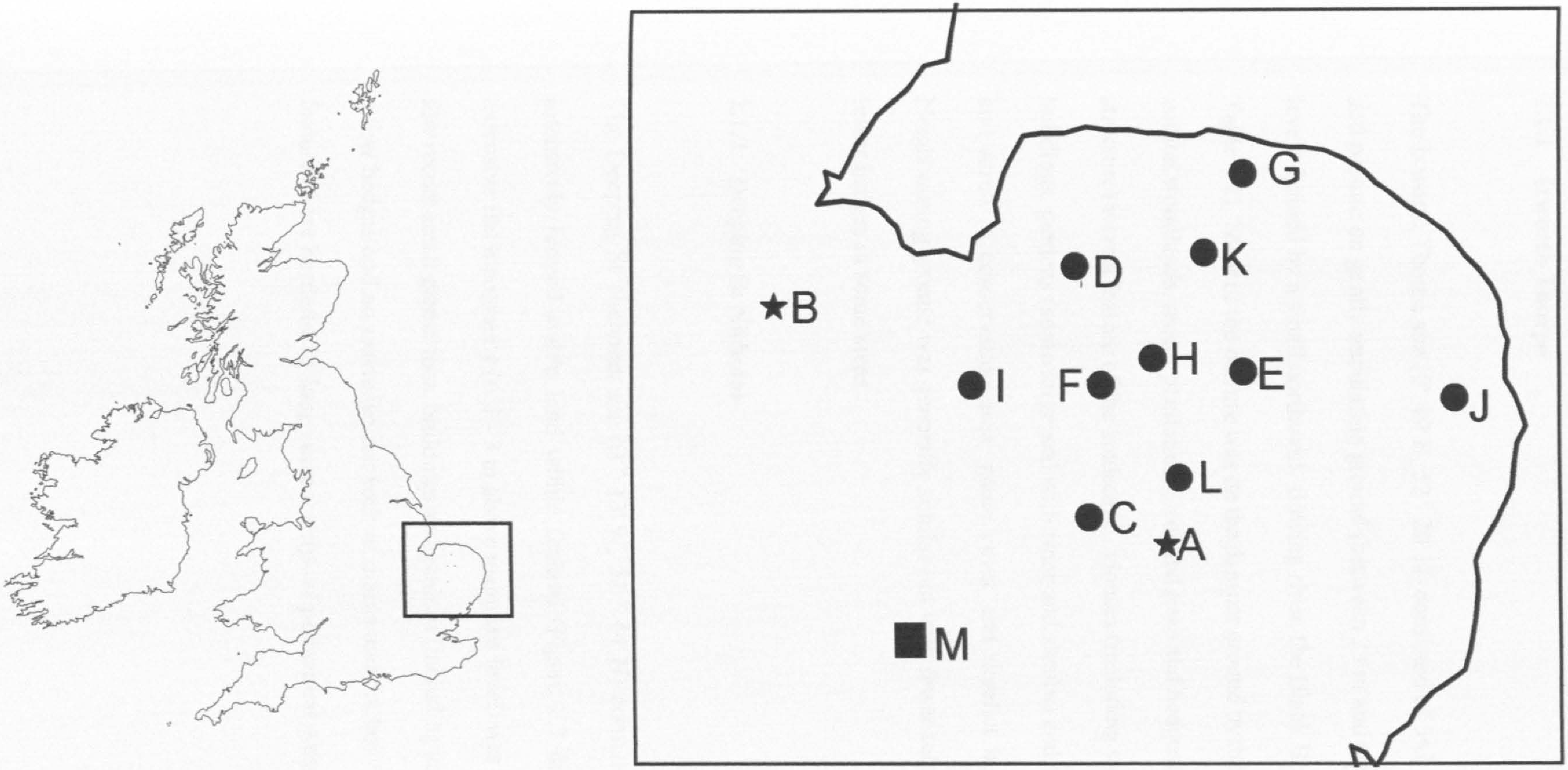


Figure 2.1 The location of the study sites used during this study. Stars mark the two intensive study areas, Ixworth Thorpe (A) and Deeping St Nicholas. (B). Circles mark the 10 experimental sites, Elveden (C), Gayton (D), Hardingham (E), Hilborough (F), Letheringsett (G), Little Dunham (H), Panworth (I), Raveningham (J), Sennowe (K) and Shadwell (L). The square gives the location of Murton's historical study at Carlton (M)

2.1.1 Ixworth Thorpe

The Ixworth Thorpe site (0° 49' E, 52 ° 20' N) consisted of 543 ha of mixed arable and pasture on gently undulating ground (between 23 m and 40 m above mean sea level) drained by a small northwest- flowing river, the Black Bourne (Figure 2.2 & Table 2.2). Most of the pasture was on the damper ground by the river. Small semi-natural woodlands, recent plantations, isolated trees and hedges (varying in size and structure) were a feature of the landscape. Houses (including small villages), other buildings, gardens (some large and with trees and shrubs) and some rough ground and scrub (a conservation area, game cover and derelict land) also occurred. Neighbouring ground was generally similar but with fewer recent plantations and fewer hedges in some areas.

2.1.2 Deeping St Nicholas

The Deeping St Nicholas site (0 ° 13' W, 52 ° 44' N) consisted of c7300 ha of intensively farmed arable land within fenland (Figure 2.3 & Table 2.2). The extensive flat topography (*c.* 2 - 3 m above mean sea level) was interspersed with a few recent small plantations, buildings and gardens (including an 'extended' village), a few hedges and an extensive network of drains and ditches. Many of the latter features were bordered by long narrow strips of permanent grass.

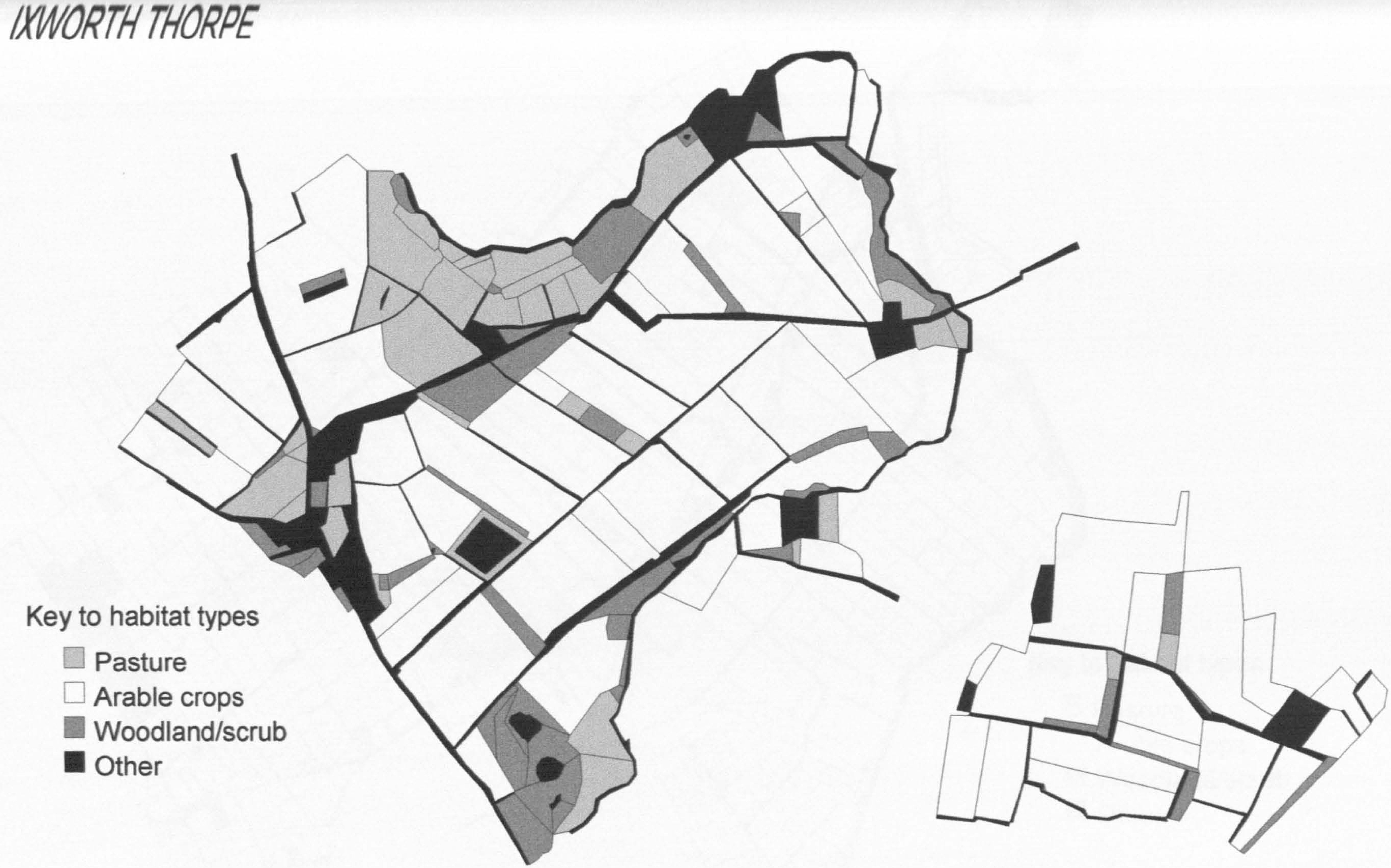


Figure 2.2 The Ixworth Thorpe intensive study site, showing the broad habitat types present during 1998-2000

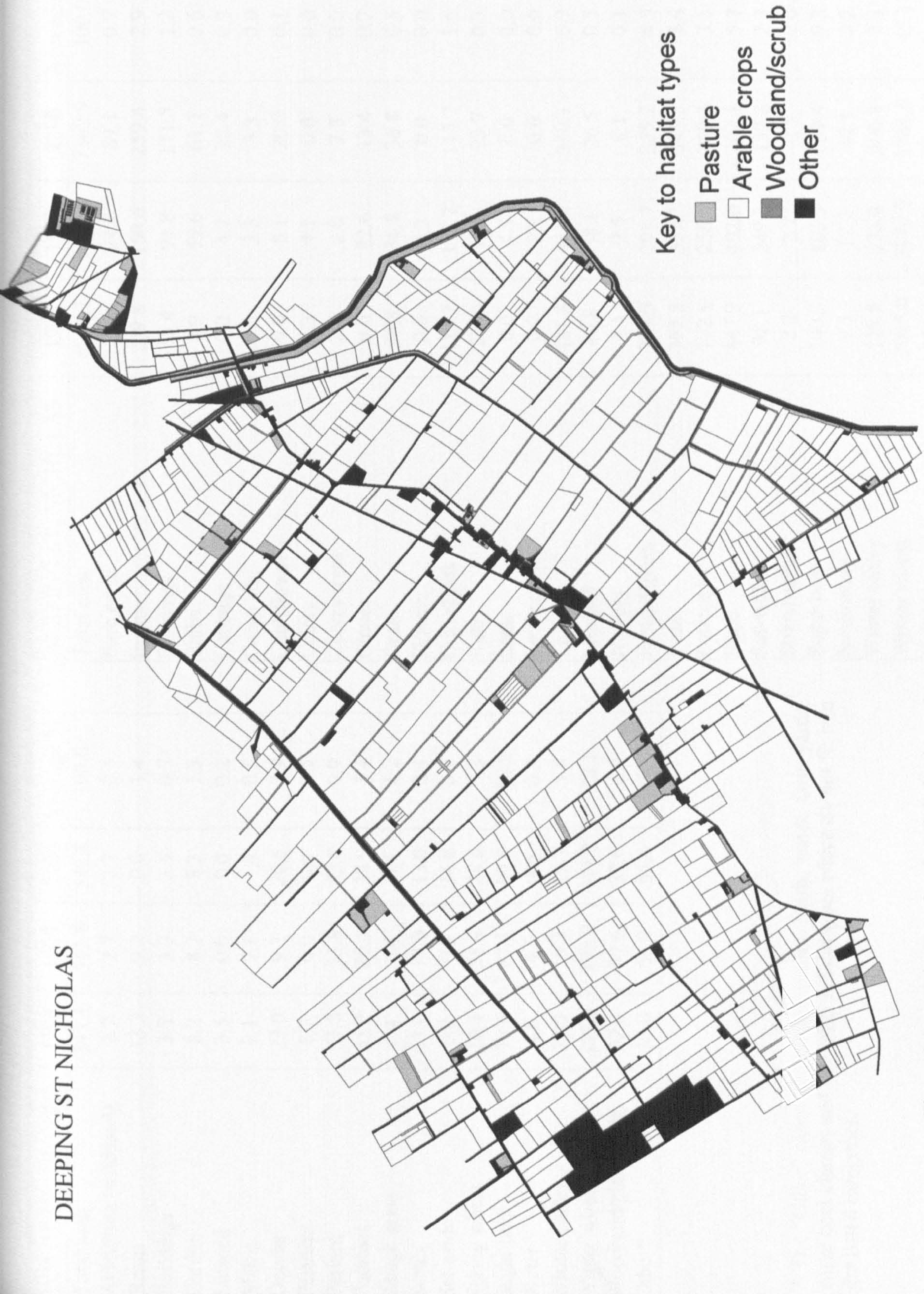


Figure 2.3 The Deeping St. Nicholas intensive study site, showing the broad habitat types present during 1998-2000

Table 2.2 Areas (ha) of each habitat and crop type within the intensive study areas at Ixworth Thorpe and Deeping St. Nicholas in the summers of 1998-2000

IXWORTH THORPE	1998	1999	2000	Average %
Total area	543.1	542.8	542.8	100.0
Aviculture (wildfowl)	2.7	2.7	2.7	0.5
Beans	13.3	9.2	0.0	1.4
Buildings	3.5	3.7	3.5	0.7
Garden	8.2	8.2	8.2	1.5
Linseed	3.5	0.0	0.0	0.2
Maize	2.1	2.1	1.0	0.3
Onions	23.0	9.2	30.6	3.9
Parsnips	8.7	0.0	0.0	0.5
Pasture	53.8	53.8	53.8	9.9
Potatoes	35.2	20.1	32.9	5.4
Rough grass	6.4	6.4	6.4	1.2
Scrub	13.0	13.0	13.0	2.4
Set-aside	0.0	0.0	14.6	0.9
Spring wheat	18.4	38.4	28.6	5.3
Sugar beet	76.6	87.1	99.4	16.2
Water	4.6	4.6	4.6	0.8
Winter barley	22.5	19.7	19.7	3.8
Winter wheat	155.0	172.0	131.2	28.1
Woodland/plantations	37.6	37.6	37.6	6.9
Other*	55.0	55.0	55.0	10.1

DEEPING ST. NICHOLAS	1998	1999	2000	Average %
Total area	6925.1	7363.0	7362.9	100.0
Bare earth	32.1	24.2	89.1	0.7
Beans	209.8	150.6	259.4	2.9
Buildings	65.4	91.8	111.5	1.2
Bulbs	8.9	59.6	61.7	0.6
Cabbage	0.0	4.2	28.4	0.2
Camp site	3.3	3.3	3.3	0.0
Cauliflower	0.0	8.1	20.0	0.1
Celery	2.3	4.1	0.0	0.0
Cherry trees	2.8	2.8	2.8	0.0
Clover	0.0	22.6	13.4	0.2
Drain	36.8	36.8	36.8	0.5
Flowers	0.0	2.3	0.0	0.0
Gravel pits	115.7	115.7	115.7	1.6
Kale	27.6	12.5	23.7	0.3
Leek	0.0	4.1	0.0	0.0
Lettuce	0.0	2.2	0.0	0.0
Linseed	481.3	463.6	330.1	5.9
Mustard	40.8	38.1	26.5	0.5
Nursery	1.1	2.5	8.1	0.1
Pasture/grass	279.0	291.7	355.2	4.3
Peas	365.5	537.3	347.5	5.8
Potatoes	192.1	256.4	260.3	3.3
Rape	447.9	492.6	302.1	5.7
Set-aside	98.1	249.3	139.8	2.3
Strawberries	2.2	2.2	2.2	0.0
Sugar beet	580.3	803.5	639.4	9.3
Sunflowers	9.1	12.9	12.1	0.2
Winter barley	119.8	133.4	206.8	2.1
Winter wheat	3015.0	2970.5	3784.6	45.1
Unknown arable	135.2	146.3	122.2	1.9
Other*	653.0	417.8	60.2	5.2

* The "Other" category includes tracks, roads, water, farm yards, sugar beet clamps and any other habitat types which do not fit into the listed categories.

2.1.3 Experimental study sites

Ten estates across Norfolk and Suffolk were chosen for the feeding experiment (Figure 2.1). The estates were at least 10 km apart, to ensure their independence. On each of the estates, a study site that could easily be surveyed in one morning and contained the most suitable habitat for Turtle Doves was selected. The study sites contained a mixture of arable crops and natural habitats, were of varying sizes and were all between 20 and 90 m above mean sea level. The study site at Little Dunham was much smaller than the other sites and contained a much smaller range of crops, but was known to support Turtle Doves. A breakdown of crops and natural habitats on each of the study sites is given in Table 2.3.

Table 2.3 Relative distribution (%) of the crop and habitat types on the ten experimental study sites, averaged over 1999-2000

	Elveden	Gayton	Hardingham	Hilborough	Little Dunham	Letheringsett	Panworth	Raveningham	Sennowe	Shadwell
Buildings	1.5	0.5	2.3	0.0	0.6	1.3	1.0	3.4	0.9	0.9
Grass (non-rotational)	3.2	0.0	9.8	9.3	0.0	17.2	7.6	11.1	8.6	12.9
Grass (rotational)	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other*	0.0	0.1	1.5	0.0	0.3	0.0	0.0	0.0	0.0	12.8
Break crop	58.1	45.6	21.3	42.4	84.4	2.5	21.2	5.0	26.4	24.6
Scrub	1.2	0.0	7.2	8.2	0.3	40.0	2.1	17.0	2.2	17.4
Set-aside	14.5	6.3	14.9	13.7	0.0	3.7	8.5	1.4	6.6	0.6
Spring cereal	0.0	13.9	6.2	3.7	9.9	5.7	0.0	10.7	2.5	0.0
Track	4.5	3.4	6.1	5.2	3.3	2.9	5.2	29.0	2.9	5.6
Water	3.1	0.0	2.9	1.3	0.0	5.9	0.0	6.3	0.0	0.0
Winter cereal	4.0	13.6	22.0	11.0	0.0	18.1	51.5	12.7	45.6	19.1
Woodland	9.8	11.3	5.8	5.2	1.1	3.0	3.0	3.7	4.2	6.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*The "Other" category includes tracks, roads, water, farm yards, sugar beet clamps and any other habitat types which do not fit into any of the listed categories

2.2 General methods

2.2.1 Trapping and marking

From mid-May, attempts were made to catch birds at each intensive study site and attach radio transmitters. At Ixworth Thorpe the territory mapping visits and incidental observations identified favoured feeding sites. The attractiveness of these feeding sites was enhanced by the addition of small amounts of supplementary food. Birds were then caught at these feeding sites using whoosh/clap nets. At Deeping St Nicholas a similar approach was used, however, many more "man-made" feeding sites existed (maintained feeding sites, grain stores and an abundance of spilt grain) and the addition of supplementary food was not required. Captured adults (excluding those fitted with radio transmitters) and nestlings were colour-ringed. The colour-marking scheme was chosen to identify the age of bird at ringing, year and site. The licence granted for the fitting of radio transmitters did not permit the fitting of colour rings on tagged birds.

At Ixworth Thorpe 51 birds were caught during mid-May and at Deeping St Nicholas 36 birds were caught between mid-May and early June. Each tagged bird was fitted with a tail-mounted transmitter of approximately 3 g and a life of about 20 weeks. The transmitters were glued to the central two tail feathers and were further secured with dental floss, which was passed through tubes attached to the radios and tied around the central tail feathers. Tail-mounted transmitters were used because Turtle

Doves are known to moult the tail before migration. All transmitters that became detached or were moulted off were collected.

Attempts were made to relocate all radio-tagged birds immediately after release to ensure that the radio transmitters were performing correctly. Each relocation fix was derived from an approximate triangulation and in most cases was confirmed visually. The number of Turtle Doves radio-tagged and subsequently monitored are summarised in Table 2.4. During 1998, the transmitters supplied were of poor quality, with a range of only about 250 m. Consequently, few useful data were collected. After field trials during the winter 1998/99, transmitters of better quality were obtained with a range of 2-3 km. Even with the improved performance, only 40% of the birds fitted with transmitters in 1999 and 2000 were relocated more than 10 times throughout the breeding season. At both sites at least four of the tagged birds were predated (most likely by Sparrowhawks) and at least five lost their transmitters soon after attachment. Unfortunately, in most cases it was not until days later, after attempting visually to confirm the relocations, that it was discovered that the transmitter was not attached to the birds, by which time catching opportunities had ceased. In 1999 some of the birds caught at Ixworth Thorpe were also fitted with transmitters from 1998, and although it was known that their performance was inferior, it was considered worthwhile attaching them as they may have provided some data. However, these transmitters did not perform well and very few relocations were obtained. Other birds that generated very few relocations were assumed to have been passage birds that moved off the study area and out of range as they continued their spring migration, having been temporarily attracted to food at the catching site.

The problem of Turtle Doves being attracted to food at the catching sites and moving off the study area is likely to be greater at Deeping St Nicholas where breeding density was very low. One radio-tagged bird was followed from within the study site towards and over Peterborough before being lost, having travelled over 15 km. An additional problem at Deeping St Nicholas in 1999 was the type of glue used for attachment. Most radios were attached using standard Superglue in a squeezable tube. This produced a drip of glue, which soaked into the feather shaft and ensured good attachment. However, some radios at Deeping St Nicholas in 1999 were attached using brush-on Superglue. The brush-on glue coated the radio with a thin film of glue that stuck only to the surface of the feather shaft and easily became detached. All detached radios that were found in the study areas early in the field season were reused on different birds, but the early timing of catching opportunities meant that those found later could not be reused.

Table 2.4 Numbers of Turtle Doves radiotagged and subsequently monitored at Ixworth Thorpe and Deeping St Nicholas, during the summers of 1998 - 2000

	Ixworth Thorpe	**Deeping St Nicholas**
1998		
Total number tagged	12	8
No fixes, bird "lost" or radio fell off	9	6
<10 fixes	2	2
10-30 fixes	1	0
>30 fixes	0	0
1999		
Total number tagged	21	15
No fixes, bird "lost" or radio fell off	8	6
<10 fixes	6	4
10-30 fixes	2	2
>30 fixes	5	3
2000		
Total number tagged	18	12
No fixes, bird "lost" or radio fell off	2	5
<10 fixes	7	2
10-30 fixes	4	0
>30 fixes	5	5

2.2.2 Resighting colour rings

Whenever Turtle Doves were encountered during fieldwork, they were thoroughly checked for the presence of colour rings, metal rings and radios (in case of malfunction).

2.2.3 Computer mapping

The MapInfo (MapInfo Corp. 1999) Geographical Information System (GIS) (Version 5.5) was used throughout this study. The system is based on a polygon representation of geographical features (i.e. fields, woodlands, roads, etc) to produce a digitised computer-based map. For all study sites, with the exception of Carlton, a digitised map was produced from large scale Ordnance Survey maps. Each polygon within the maps was effectively a database that included information on habitat, land use, area and other data such as pesticide usage. A GIS map was created for all years of the intensive study (1998-2000) for the two years of the experimental study (1999-2000) and for each of the plots used in the CBC analysis (see later).

The GIS was used to provide much of the information used within many of the statistical procedures carried out in this study. The GIS was used to measure distances (e.g. foraging distance), area (e.g. territories and home ranges) and to provide habitat compositions of a block of land (e.g. study sites, territories, home ranges, and buffers around fixed plots). The GIS was also used to produce maps to present data.

2.3 Statistical analysis

2.3.1 Compositional analysis

Compositional analysis (Aitchison 1986), as developed by Aebischer *et al.* (1993a,b) to analyse habitat data, was used throughout this study.

The analysis of compositional data, i.e. multivariate data made up of a set proportions, is complicated by the fact that all proportions within a set sum to one. This is known as the 'unit-sum constraint', whereby the dimensionality of the dataset is c-1 rather than c. So in a two-category composition, the proportional value of one category is linearly related to the other, and an analysis of the variation of one of the categories is equivalent to an analysis of the variation in the other category. Compositional analysis overcomes this problem by transforming the proportions to logratios, whereby one of the categories acts as the denominator in a series of divisions involving the other categories, making them linearly independent. The resulting ratios are transformed to logarithms to normalise their distribution. If a habitat category has a proportion of zero it is not possible to calculate a logratio. To overcome this problem the zero value is replaced with a positive value that was less than the smallest recorded non-zero proportion, usually 0.001 (Aebischer *et al.* 1993b). To investigate habitat use in relation to habitat availability, subtracting the ratio of available habitat from the corresponding ratio of habitat use yields a logratio difference that should be zero if use equals availability.

The logratio differences can then by analysed using multivariate analysis of variance (MANOVA), to test the null hypothesis of random habitat use (logratio differences not significantly different from zero) based on Wilk 's Lambda "Λ" statistic. If use is significantly non-random, habitats are ranked according to relative use by constructing a matrix derived from the ratio of the mean and standard error of each logratio difference, which produces a *t* value, measuring the departure from random use of each pair of habitats. The *t*-values are replaced within a ranking matrix with a + or – symbol for ease of interpretation. A triple positive sign in the matrix indicates that the row habitat is used significantly more that the column habitat relative to their availability ($P < 0.05$). A triple negative sign indicates the opposite.

2.3.2 Breeding success

The estimation of breeding success is a fundamental aspect of ornithological study. The easiest way of depicting breeding success is to produce a ratio of successful nests from a total number of nests studied. However, this has the inherent bias that unless all nests are found at the start of nesting it is likely that nests which fail early will be overlooked and the estimate produced would be biased towards those that are successful. To overcome this, Mayfield (1961) developed a method to estimate daily nest survival probabilities (see also Mayfield 1975, Hensler & Nichols 1981, Hensler 1985). This method provides an estimate that is unbiased by taking into account the number of days during which the nest was monitored; it assumes a constant daily survival rate. The Mayfield method has been developed statistically and expanded to allow a standard error to be calculated (Johnson 1979, Hensler & Nichols 1981). The Mayfield method has been further extended by Aebischer (1999) to allow the analysis of daily survival probabilities using generalised linear modelling (GLM) to test for the effect of continuous variables and factors (Aebischer 1999). Essentially this extension allows complex Mayfield models to be fitted using logistic regression (GLM with logistic link function and binomial error term). The nest forms the unit of analysis and the response variable (number of successful observation days) is calculated as $s = t + y - 1$, where t is the number of days the nest was monitored, y is nest outcome (0 for failure and 1 for success). The term t also represents the number of binomial trials within the analysis.

The Aebischer (1999) extension of the Mayfield method is used throughout this study. The exact approach used is detailed in the relevant sections of this thesis, but a few general rules and assumptions apply. Nests were considered successful during the incubation stage if one or more eggs hatched, and during the nestling stage if one or more chicks fledged. Partial losses were not considered in the analysis. Only nests visited at least twice were included in the analysis. If the exact date of hatching, fledging or failure was not known, the mid-point of the range of possible days was used.

CHAPTER 3

BREEDING BIOLOGY

3.1 Introduction

Population levels are maintained through the balancing of fecundity, mortality, immigration and emigration (Lack 1954, Siriwardena *et al.* 2000). The population declines experienced by Turtle Doves must therefore be due to an imbalance of these four life stages. In order to establish the role of fecundity in causing the decline of Turtle Doves an investigation into the breeding ecology of the species was undertaken. The results obtained from this study were compared with those collected during the 1960s (Murton 1968) to establish if changes in breeding performance had occurred over the last 40 years.

A number of studies have shown how the availability and quality of nesting habitat effects the diversity and abundance of a range of bird species (Arnold 1983, Green *et al.* 1994, Parish *et al.* 1994, 1995, Macdonald & Johnson 1995). One of the main habitats that have been affected by agricultural intensification has been hedges, farm woodlands and scrub. As these habitats are used by Turtle Doves predominately for nesting it is likely that the territory density of the species is dependent on their availability. In order to establish the importance of these habitats the species territory habitat requirements were assessed.

Breeding Turtle Doves have been studied in many European countries (Holzwarth 1971, Kraus *et al.* 1972, Cederwell 1978, Kotov 1974, Pikula & Beklova 1984, Bijlsma 1985, Genard 1989, Peiró 1990, Nankinov 1994a, Nankinov 1994b, Dias & Fontoura 1996, Dias *et al.* 1996). The only major study in the UK (and therefore most relevant for this study) was undertaken at a site based around the village of Carlton, near Newmarket in Cambridgeshire (Murton 1968). In addition to his field-based study, Murton also undertook an analysis of nest record cards submitted to the BTO up to 1966. A comparison of Murton's findings and those from this study is undertaken later in this chapter.

The Turtle Dove breeding season starts immediately after arrival on the breeding grounds in late April and concludes with the start of autumn migration in early August. The nest is usually a small platform of thin sticks built by the female with the occasional assistance of the male. Sometimes other materials such as thin wire and plastic are included in the nest. The nest is normally sited in bushes and trees, either within scrub, in hedgerows or in isolated bushes. Clutches vary from between one to three eggs with two being typical. Turtle doves may produce up to three successful broods, but may nest more than three times if a brood is lost and a replacement clutch laid. Incubation is undertaken by both sexes and lasts 13-16 days. Nestlings are cared for by both parents and leave the nest after about 20 days. Birds are able to breed in their first year of adulthood. Previous studies suggest that about half the eggs laid are successful, with the remainder being predated, deserted or failing to hatch owing to infertility (Cramp 1985, Murton 1968).

3.2 Methods

3.2.1 Territory mapping

At Ixworth Thorpe, territory mapping visits were carried out on foot every two weeks on an area of 543 ha (Figure 2.2). Each territory mapping visit took place between 04:30 and 10:00 BST (Calladine *et al.* 1999) and required 2-3 days to complete. The route followed was chosen so that it passed all areas suitable for Turtle Doves on the site, to maximise the chance of detecting birds present. All forms of behaviour shown by the birds were mapped. The route and direction taken was varied between visits to eliminate any time-related bias. All territory mapping visits were undertaken between early May and late August.

The area surveyed at Deeping St Nicholas was much larger in size (~7000 ha) (Figure 2.3) so a slightly different approach was used. Between early May and late August, at regular intervals (usually 3 weeks), a bicycle was used to follow a route that passed all areas of suitable habitat, including hedges, plantations, areas of scrub and residential gardens. In addition to the information recorded on the territory mapping visits, any observations of Turtle Doves made whilst carrying out other work were also recorded.

The locations of all birds showing territorial behaviour were plotted onto computerised maps of the study sites. These were prepared using the MapInfo Professional 5.5 GIS (MapInfo Corp. 1999) and included details of all habitat and crop types. Using the protocol outlined in Bibby *et al.* (2000), clusters of territorial bird locations were defined as territories. At least two locations were required to establish a cluster. Birds seen displaying at feeding sites or communal roosting sites were excluded.

Having identified each cluster, a boundary was established around its "defended" area by fitting a 50-m buffer around all the locations within it. If appropriate this buffered area was modified to produce non-overlapping rings around each cluster (Bibby *et al.* 2000). The area within the boundary is regarded here as the nesting territory and contains the nesting habitat. The area of the territories and the proportions of each habitat within them were determined using the GIS.

3.2.2 Finding nests

Nests were found at both study sites using the same techniques. The nests of radio-tagged doves were relatively easy to find. For non-tagged doves, the territory mapping and other general observations gave a general location of a bird's breeding territory. Within these territories all suitable nesting areas (principally Hawthorn scrub) were searched to locate the nest. This approach was more productive at Deeping St Nicholas where hedges were less numerous and widely distributed.

3.2.3 Monitoring nests

The location, height above ground level, species and size of tree or shrub, presence, proximity and species of any climbing plants and distance from trunk/edge was recorded for each nest. Distances were recorded to the nearest centimetre. All accessible nests were visited at intervals of 3-4 days to monitor their outcome. For nests that were not easily accessible or were out of reach, a mirror attached to a pole was used to view nest contents.

Biometric information was collected from all accessible nestlings, usually at the time of ringing. The weight and tarsus length was collected from chicks at age 3-8 days. Nest disturbance was kept to a minimum during the early egg stage and after the chicks were older than 10 days, to reduce the risk of being abandoned and nestlings prematurely fledging.

3.2.4 Finding missed nests

After leaf fall all suitable nesting habitat was searched to locate nests that were missed during the breeding season. Information about the nesting site (section 3.2.3) was collected. Searches for missing nests were carried out on 18/12/1999 and 15/11/2000 at Ixworth Thorpe and on 20/12/1999, 22/12/1999 and 17/11/2000 at Deeping St Nicholas.

3.3 Statistical analysis

3.3.1 Territory composition

The habitat requirements of nesting Turtle Doves were investigated by comparing the proportional area of habitats contained within each territory with that available within the entire study site, using compositional analysis (Aebischer *et al.* 1993a, b). In order to avoid habitat comparisons containing large numbers of unused habitat types, which could bias the statistical analysis (Aebischer *et al.* 1993a), the number of habitat types was reduced to the following five broad types: 1) Cereals (all cereal crops), 2) Break crops (all non-cereal arable crops), 3) Grass (all grassland, temporary and permanent, rough ground and set-aside) 4) Wood (all woodland, hedges, scrub, and large gardens) and 5) Other (all other habitat types, including roads, buildings, water, etc).

3.3.2 Nest success

Analysis of daily survival probabilities was carried out using an extension of the Mayfield method based on generalised linear modelling using logistic regression (Aebischer 1999). The analysis was performed on data from both intensive sites collected over the three years of the study, and tested for year and site effects, and their interaction.

Only pairs for which I was confident that all nesting attempts were identified were used to calculate the number of clutches and young produced per pair per annum. These were either radio tagged pairs (60%) or pairs which were located in habitats which were easy to search for nests and for which the chronology of nesting implied that successive nesting attempts had taken place (40%). Non radio-tagged pairs that had their territories located in tall and dense woodland or scrub and those that had unexplained gaps in the recorded information about the breeding season were excluded from these calculations.

3.4 Results

3.4.1 Territory density

Between 22 and 25 Turtle Dove territories were located annually at Ixworth Thorpe during the period 1998-2000, representing an average density of 4.3 (range 4.1-4.6) territories per km^2. The maximum number of territories recorded at one time was 17-18 (depending on year), during the first two weeks of June (Figure 3.1), equivalent to an average density of 3.3 territories per km^2. The discrepancy implies that some males moved territories during the breeding season. The number of recorded territories increased during May as birds returned from their wintering grounds until the peak was reached (Figure 3.1).

At Deeping St Nicholas the number of territories located annually during the 1998-2000 breeding seasons varied between 24 and 32, yielding an average density of 0.4

(range 0.3-0.5) territories per km^2. The maximum number of territories located in any one period was 19-26 (Figure 3.1), representing a density of 0.3 territories per km^2. There was no obvious temporal trend in the number of territories from mid-May to the end of July that was common to all years (Figure 3.1).

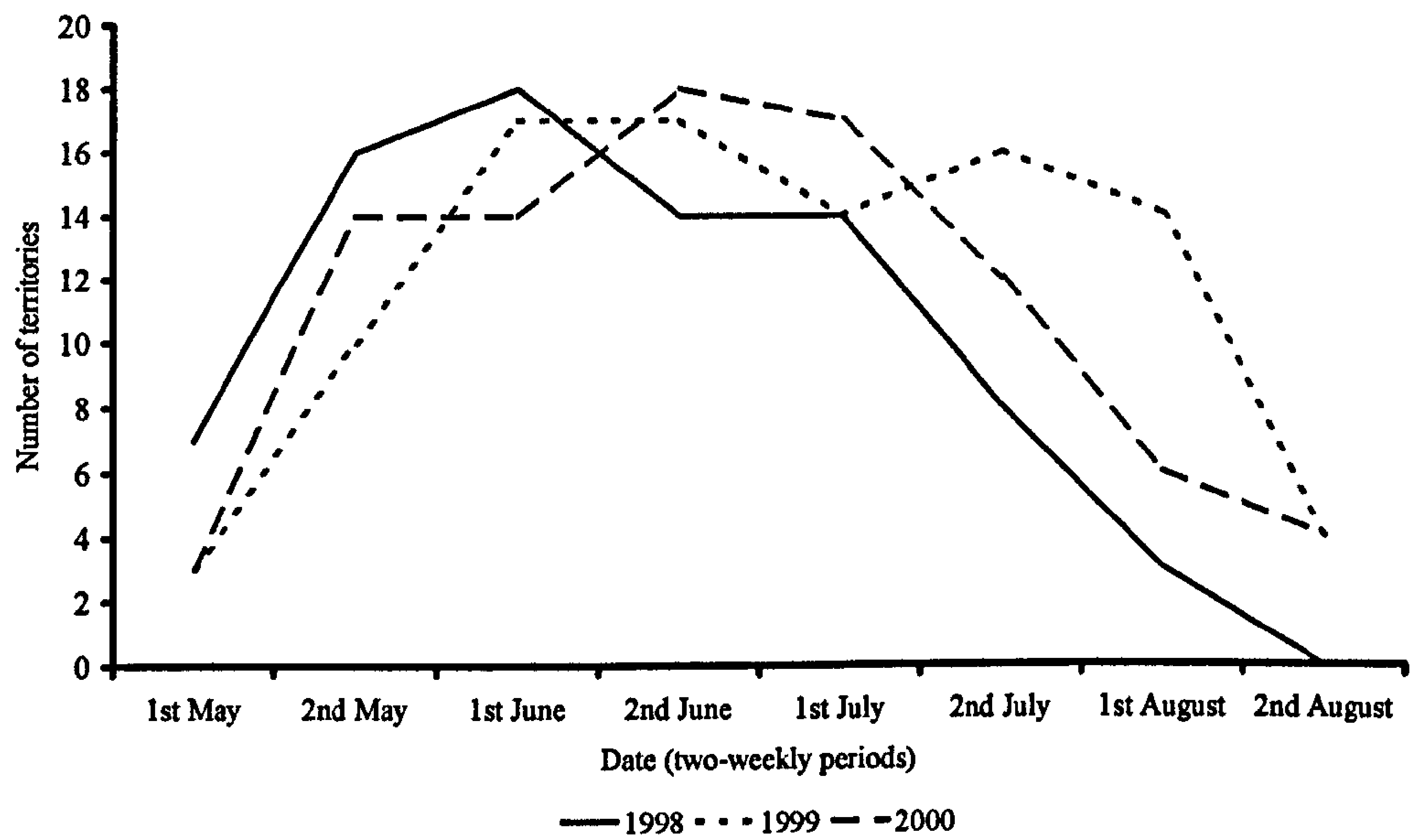


Figure 3.1a The number of apparently occupied Turtle Dove territories recorded throughout the 1998-2000 breeding seasons at Ixworth Thorpe

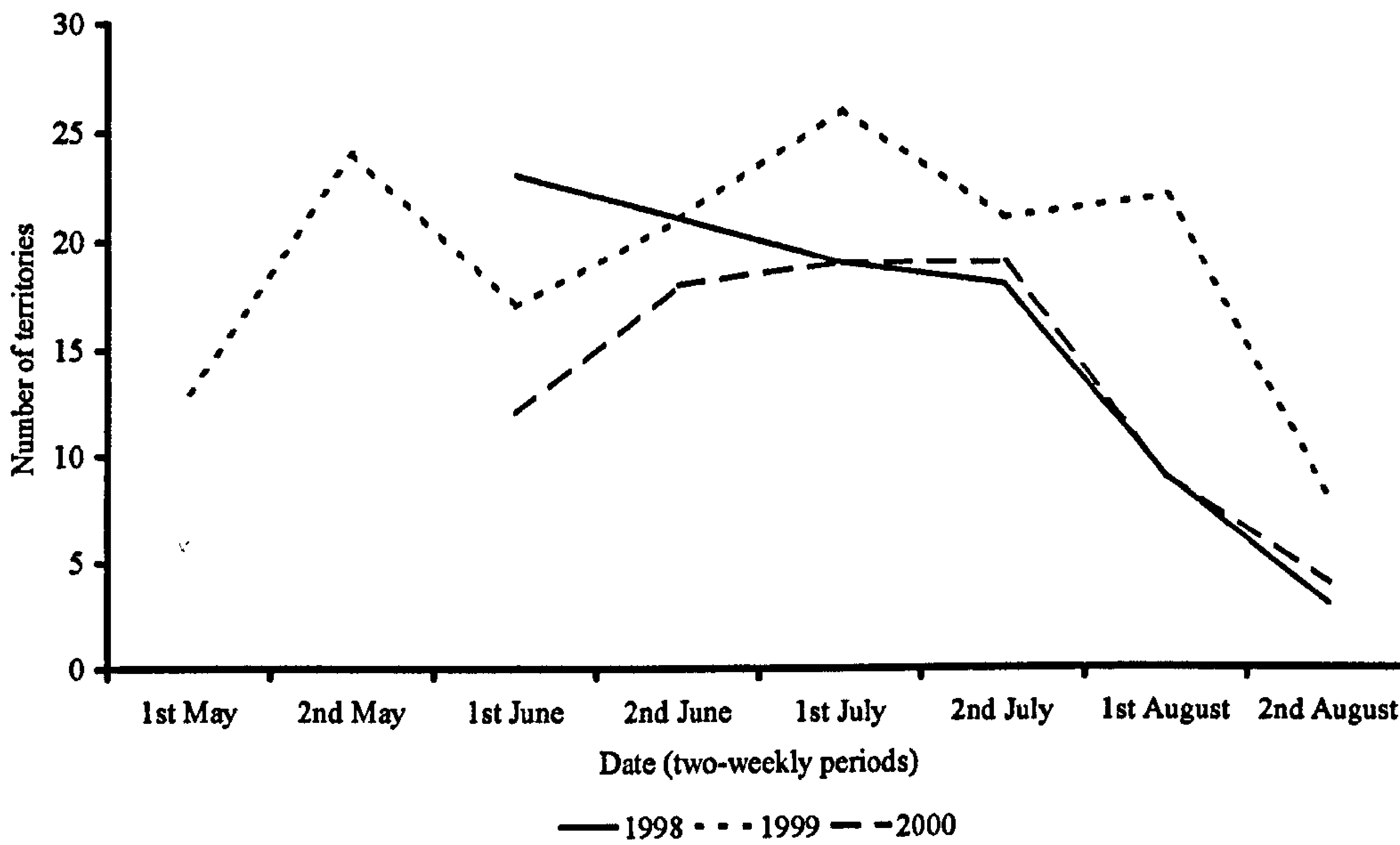


Figure 3.1b The number of apparently occupied Turtle Dove territories recorded throughout the 1998-2000 breeding seasons at Deeping St Nicholas

3.4.2 Territory habitat requirements

The mean size (± 1 s.e.) of 71 nesting territories at Ixworth Thorpe was 1.91 ± 0.18 ha (range 0.75-8.90) (Table 3.1). At Deeping St Nicholas, the mean size of 87 nesting territories was significantly larger at 3.08 ± 0.38 ha (range 1.57-4.49) ($t_{156} = 2.65$, $P = 0.009$).

Table 3.1 Territory size, habitat availability (% of study site) at each intensive study area during 1998-2000 and habitat composition of Turtle Dove territories (% of habitat within territory).

	Area (ha)	Cereals	Break crops	Grass	Woodland	Other
Ixworth Thorpe						
1998 (22 territories)						
Study area		36.0	30.0	11.0	10.0	13.0
Territory (mean ± s.e.)	2.3 ± 0.4	14.0 ± 4.2	10.8 ± 4.9	20.5 ± 5.3	34.9 ± 6.4	19.7 ± 5.1
1999 (25 territories)						
Study area		26.0	37.0	16.5	10.5	10.0
Territory (mean ± s.e.)	1.4 ± 0.2	12.1 ± 3.4	4.1 ± 1.6	23.7 ± 5.3	46.8 ± 4.6	13.3 ± 3.1
2000 (24 territories)						
Study area		33.2	30.30	13.82	11.88	10.85
Territory (mean ± s.e.)	2.1 ± 0.3	13.9 ± 5.1	5.3 ± 1.7	24.1 ± 5.3	32.4 ± 5.5	24.3 ±4.7
Overall (71 territories)						
Study area mean		31.7	32.4	13.7	10.8	11.3
Territory (mean ± s.e.)	1.9 ± 0.2	13.4 ± 0.2	6.7 ± 0.4	22.8 ± 0.3	38.1 ± 0.9	19.1 ± 0.7
Deeping St. Nicholas						
1998 (31 territories)						
Study area		45.3	38.0	7.1	0.7	9.0
Territory (mean ± s.e.)	4.5 ± 9	26.4 ± 4.8	19.2 ± 3.8	23.1 ± 4.5	0.0 ± 0.0	31.5 ± 3.2
1999 (32 territories)						
Study area		43.1	39.9	7.5	0.8	8.8
Territory (mean ± s.e.)	2.8 ± 0.3	17.6 ± 4.1	22.2 ± 4.2	27.9 ± 4.8	7.2 ± 1.5	25.2 ± 3.9
2000 (24 territories)						
Study area		52.8	30.7	6.7	0.8	9.1
Territory (mean ± s.e.)	1.6 ± 0.2	20.6 ± 4.3	16.7 ± 5.7	23.3 ± 4.6	9.7 ± 3.1	29.7 ± 5.1
Overall (87 territories)						
Study area mean		47.1	36.2	7.1	0.8	8.9
Territory (mean ± s.e.)	3.1 ± 0.4	21.3 ± 2.6	19.4 ± 2.6	24.6 ± 2.7	5.3 ± 1.1	29.5 ± 2.3

At both sites, habitat composition of the territories differed significantly from random (Ixworth Thorpe: $\Lambda = 0.194$, $F_{4,67} = 69.49$, $P < 0.001$; Deeping St Nicholas: $\Lambda = 0.373$, $F_{4,78} = 32.85$, $P < 0.001$). The habitat compositions of the territories are given in Table 3.1. Turtle dove nesting territories contained on average more woodland, grassland and other non-crop habitats and less cropped habitats than was generally available on the study site (Figure 3.2). The ranking matrix for Ixworth Thorpe (Table 3.2) indicated Wood>>>Other>Grass>>>Cereals>Break Crops, confirming that territories contained significantly more non-cropped habitats than cropped ones relative to availability. The same pattern was recorded at Deeping St Nicholas (Table 3.2), where the ranking matrix indicated Other>>>Grass>>>Wood>>>Break Crops>Cereals. Other habitats including farmyards, small gardens, areas of rough ground, etc.

Table 3.2 Ranking matrix for Turtle Doves at Ixworth Thorpe and Deeping St Nicholas based on comparing the habitat composition within Turtle Dove territories with that within the study site (all years pooled). The positive sign indicates that the row habitat was used more than the column habitat, relative to availability, and the minus sign means the opposite. A triple sign indicates that the difference was significant at $P < 0.05$.

Ixworth Thorpe	**Cereals**	**Break crops**	**Grass**	**Wood**	**Other**	**Rank**
Cereals		+	---	---	---	1
Break crops	-		---	---	---	0
Grass	+++	+++		---	-	2
Wood	+++	+++	+++		+++	4
Other	+++	+++	+	---		3

Deeping St Nicholas	**Cereals**	**Break crops**	**Grass**	**Wood**	**Other**	**Rank**
Cereals		+	---	---	---	1
Break crops	-		---	---	---	0
Grass	+++	+++		+++	---	3
Wood	+++	+++	---		---	2
Other	+++	+++	+++	+++		4

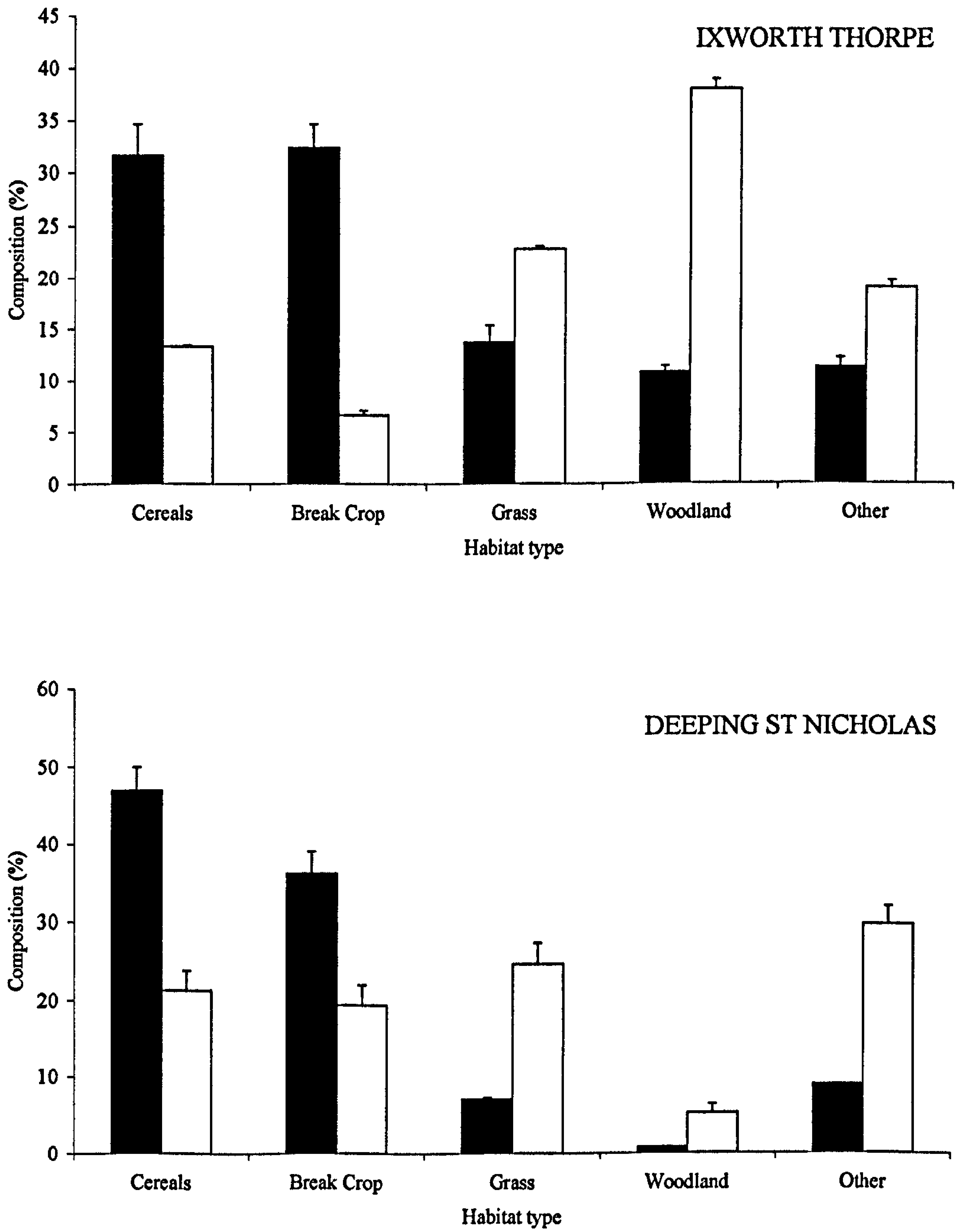


Figure 3.2 Mean habitat availability (black bars) at Ixworth Thorpe ($n = 71$) and Deeping St Nicholas ($n = 87$) and mean composition of Turtle Dove territories (white bars) at each site, averaged over 1998-2000. Error bars represent 1 standard error.

3.4.3 Nest-site utilisation

Over the three years, a total of 143 nests was found, 50 at Ixworth Thorpe and 93 at Deeping St Nicholas. Overall, the majority of nests were found within hedgerows (42%), scrub (25%), some within young plantations and woodland (18%) and the rest in isolated bushes (15%) (Table 3.3). The habitat used for nest sites was significantly different at the two sites ($\chi^2_3 = 30.1, P < 0.001$), with scrub and woodland being used more at Ixworth Thorpe and hedges and isolated bushes being used more at Deeping St Nicholas. Hawthorn was the most used tree species for nesting, with 53% of nests being found within it. Other nests were found in Norway Spruce (17%), Elder (14%) and Apple (6%). All nests were between 0.1 m and 20 m (median = 1.9 m) above ground level (Table 3.4). Nest height was significantly different at the two study sites (Mann-Whitney $U = 1144$, $n = 50, 93$, $P < 0.001$), with nests being higher at Ixworth Thorpe (median 2.6 m) than at Deeping St Nicholas (median 1.8 m). At Ixworth Thorpe, 62% of nests were within 0.05 m of climbers and in most cases climbers were an integral part of the nest, as reported in France (Aubineau & Boutin 1998); it is believed that climbers provide additional support to the nest structure (Table 3.4). However, at Deeping St Nicholas fewer climbers (25%) were observed at the nest sites. The majority of nests were located within 1 m of the edge of the bush/tree (Table 3.4).

Table 3.3 Habitat and tree species in which Turtle Dove nests were found at Ixworth Thorpe and Deeping St Nicholas in 1998-2000

	Ixworth Thorpe					Deeping St Nicholas				
	1998	**1999**	**2000**	**Total**	**%**	**1998**	**1999**	**2000**	**Total**	**%**
Habitat										
Woodland/ Plantations	1	5	9	15	30.0	1	6	3	11	11.8
Scrub	3	12	7	22	44.0	3	5	6	14	15.1
Hedgerow	5	1	5	11	22.0	13	10	26	49	52.7
Isolated trees	1		1	2	4.0	2	8	9	19	20.4
Trees species										
Alder				0	0.0			1	1	1.1
Apple		3	1	4	8.0		3	1	4	4.3
Blackthorn		1	2	3	6.0	1			1	1.1
Bramble				0	0.0		1	2	3	3.2
Elder	3	4	1	8	16.0	2	1	7	10	10.8
Guelder Rose		1		1	2.0				0	0.0
Hawthorn	4	3	7	14	28.0	16	22	30	68	73.1
Lilac				0	0.0			1	1	1.1
Poplar				0	0.0			1	1	1.1
Dog Rose			1	1	2.0		2		2	2.2
Norway Spruce	3	6	9	18	36.0				0	0.0
Snowberry				0	0.0			1	1	1.1
Willow			1	1	2.0			1	1	1.1

Table 3.4 Nest location variables (mean ± s.e.) for Turtle Doves at Ixworth Thorpe and Deeping St Nicholas, 1998-2000. The values for distance from climbers are only for nests which were in close proximity (<2 m) of climbers, not all nests were near climbers (see section 3.4.3).

	Number of nests	Height of bush (m)	Nest height (m)	Distance from Trunk (m)	Distance from Edge (m)	Distance from Climbers (m)
Ixworth Thorpe						
1998	10	4.9 ± 1.2	2.3 ± 0.5	0.8 ± 0.3	1.3 ± 0.2	0.1± 0.1
1999	18	6.1 ± 1.3	4.1 ± 1.1	0.5 ± 0.2	0.8 ± 0.2	0.1± 0.1
2000	22	6.8 ± 1.1	4.2 ± 0.9	0.9 ± 0.2	1.1 ± 0.2	0.1± 0.1
Overall mean	50	6.2 ± 0.7	3.7 ± 0.5	0.8 ± 0.2	1.1 ± 0.1	0.1± 0.1
Overall median	50	4.4 ± 0.9	2.6 ± 0.6	0.4 ± 0.3	0.9 ± 0.1	0.1± 0.1
Overall range	50	2.0 – 25.0	1.2 - 20.0	0.0 - 3.5	0.1 - 2.2	0.0 - 0.2
Deeping St. Nicholas						
1998	19	2.8 ± 0.2	1.6 ± 0.2	0.4 ± 0.1	0.8 ± 0.1	0.1 ± 0.1
1999	29	3.8 ± 0.3	2.2 ± 0.2	0.7 ± 0.1	0.8 ± 0.1	0.1 ± 0.1
2000	45	3.7 ± 0.3	2.1 ± 0.1	0.6 ± 0.1	0.5 ± 0.1	0.1 ± 0.1
Overall mean	93	3.6 ± 0.2	2.0 ± 0.1	0.6 ± 0.1	0.6 ± 0.1	0.1 ± 0.1
Overall median	93	3.3 ± 0.3	1.8 ± 0.1	0.5 ± 0.1	0.6 ± 0.1	0.1 ± 0.1
Overall range	93	1.8 – 13.0	0.1 - 4.1	0.0 - 1.8	0.0 - 3.1	0.0 - 1.2
Both sites						
Mean	143	4.5 ± 0.3	2.6 ± 0.2	0.7 ± 0.1	0.8 ± 0.1	0.1 ± 0.1
Median	143	3.6 ± 0.4	1.9 ± 0.3	0.5 ± 0.1	0.6 ± 0.1	0.1 ± 0.1
Range	143	1.8 – 25.0	0.1 - 20.0	0.0 - 3.5	0.0 - 3.1	0.0 - 1.2

3.4.4 Timing of breeding

Turtle doves started territorial behaviour (singing and flight displays) almost as soon as they arrived in the UK in late April and early May. However, no clutches were initiated until the second half of May (Figure 3.3). At Ixworth Thorpe, laying took place from the last two weeks of May through to the last week of July, with the peak during the first two weeks of June. At Deeping St Nicholas, the nesting period continued for a further four weeks, with nests being initiated through to the end of August. The peak of laying at Deeping St Nicholas was during the last two weeks of June. Overall there was no significant difference in the pattern of egg laying at the two sites ($\chi^2_5 = 9.5, P = 0.092$).

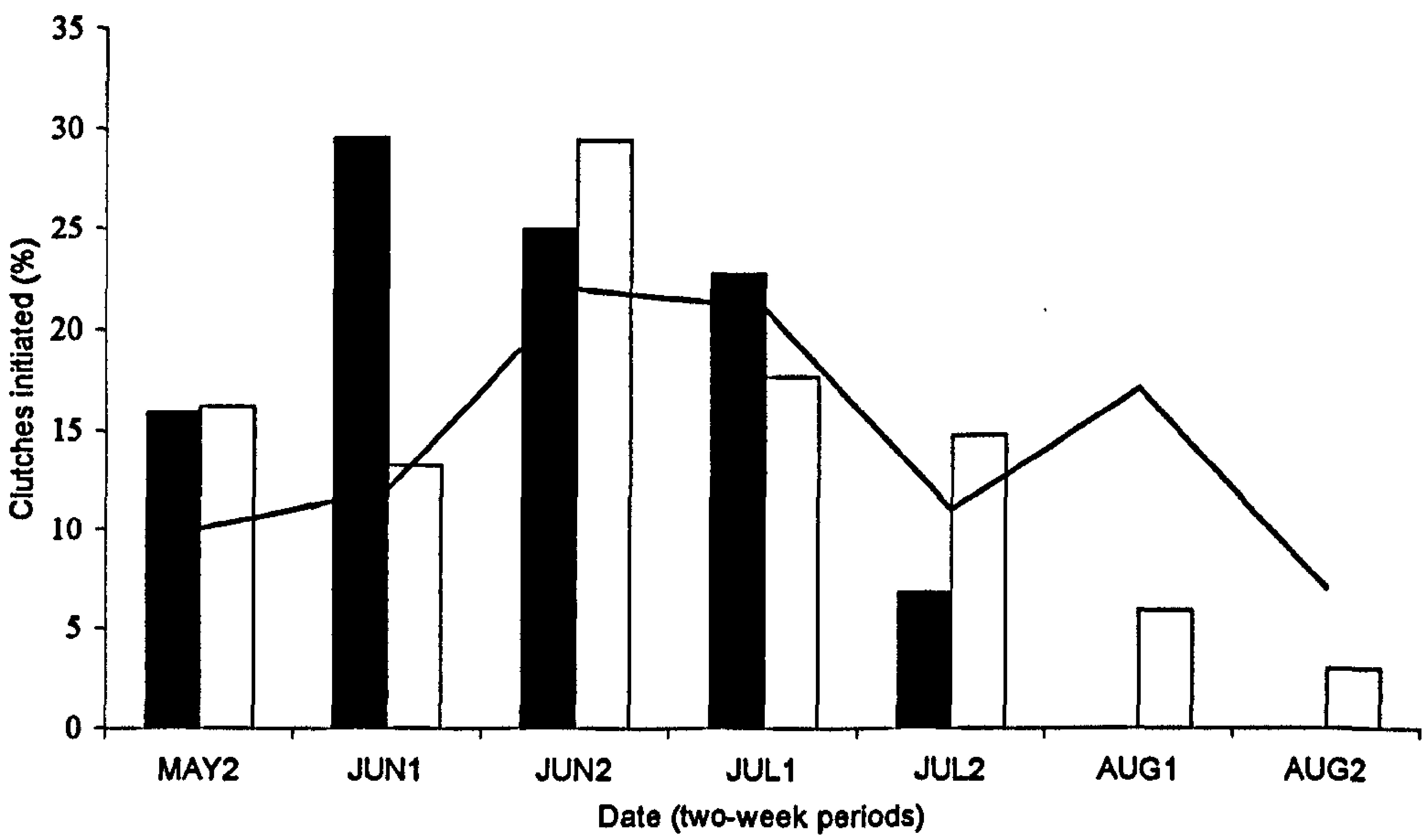


Figure 3.3 The frequency of clutches (%) initiated during each two-week period of the breeding season at Ixworth Thorpe (black bars, $n = 44$) and Deeping St Nicholas (white bars $n = 68$), combining data from 1998-2000. The data from Murton's study at Carlton is also shown (black line $n = 72$)

3.4.5 Clutch size, incubation and nestling period

For all nests in which the number of eggs laid was known ($n = 99$), clutch size was 1.9 ± 0.1 (Table 3.5). The exact number of nesting attempts made throughout the breeding season was known for 49 pairs (Table 3.5). Of these one pair had five nesting attempts, three pairs had four nesting attempts, nine pairs had three nesting attempts, 24 pairs had two nesting attempts and a further 12 pairs had only one nesting attempt. Only eight of the 49 pairs fledged more than two young, five fledged four young and three fledged three young. For nests whose hatching and fledging dates were known, the incubation period averaged 14.2 ± 0.3 days (11-17 days, n = 27) and the nestling period 15.3 ± 0.5 days (10-19 days, n = 14). At all nests that successfully fledged young, droppings were scattered around the nest site, indicating that before fledging completely, nestlings would venture out onto the branches surrounding the nest.

Table 3.5 Summary of Turtle Dove nesting information for each intensive study site during 1998-2000

	Nests found	Clutch size		Incubation period		Nestling period		Pairs studied	Number of pairs producing multiple clutches				
		N	Mean	N	Days	N	Days		1	2	3	4	5
Ixworth Thorpe													
1998	10	7	2.0	3	14.3	1	15.0	5	2	3			
1999	18	14	1.9	3	16.3	4	16.0	9	5	3	1		
2000	22	19	2 .0	3	15.0	2	18.5	11	5	4	1	1	
Overall	50	40	1.9	9	15.3	7	16.6	25	12	10	1	1	
s.e.			0.1		0.3		0.6						
Deeping St. Nicholas													
1998	19	10	2 .0	3	12.0	3	15.3	5	3	1			
1999	29	17	1.9	0	N/a	0	N/a	8	2	2	1	1	
2000	45	32	1.8	4	13.9	4	13.0	11	3	5		1	
Overall	93	59	1.8	7	13.6	7	14.0	24	8	8	1	2	
s.e.			0.1		0.4		0.5						
Both Sites													
Overall	143	99	1.9	27	14.2	14	15.3	49	20	18	2	1	
s.e.			0.1		0.3		0.5						

3.4.6 Breeding success

Of the 50 nests found at Ixworth Thorpe, 23 (36%) successfully fledged young (Table 3.6). Nine (18%) of the remaining 27 nests were abandoned, six (12%) before and three (6%) during the egg stage, the 18 other nests (36%) were predated by either Magpies or Jays during either the egg or nestling stage. Overall at Ixworth Thorpe the eggs from 38 nests were incubated during 366 observation-days (Table 3.7). Assuming an incubation period of 14 days, the nest success rate (proportion of incubated clutches that successfully hatched at least one egg) was estimated at 55.7 ± 8.4% (after Mayfield 1975). Young were reared in 26 nests during 293 observation-days. Assuming a fledging period of 15 days, nest success rate (proportion of hatched broods that successfully fledged at least one chick) was estimated at 77.3 ± 8.9%. Of the 93 nests found at Deeping St Nicholas, 31 (33%) successfully fledged young. One pair lost one nest to bad weather, 35 (38%) nests were abandoned and 25 (27%) nests were predated, most probably by magpies. At Deeping St Nicholas, eggs from 50 nests were incubated during 403 observation-days (Table 3.7), giving an estimated nest success rate during incubation of 50.8 ± 7.9% (after Mayfield 1975). Young fledged from 38 nests during 372 observation-days, giving an estimated nest success rate during brood-rearing of 56.3 ± 8.6%.

During the incubation stage, nest success rates were not significantly different at the two sites ($F_{1,84} = 0.07$, $P = 0.791$) or during the three years of the study ($F_{2,84} = 0.57$, $P = 0.567$), nor was there a significant interaction between site and year ($F_{2,82} = 0.34$, $P = 0.714$). During the nestling stage there was no significant difference in nest success rates at the two sites ($F_{1,61} = 1.77$, $P = 0.188$) or during the different years of the study ($F_{2,61} = 0.42$, $P = 0.662$), nor was there a significant interaction between site and year ($F_{2,60} = 0.29$, $P = 0.745$).

Accordingly, all data from both sites in all years were combined to give an overall estimate of nest success. Overall at both sites, eggs were incubated during 769 observation-days (Table 3.7). Assuming an incubation period of 14 days, nest success rate was estimated at 53.1 ± 5.7% (after Mayfield 1975). Young were reared during 665 observation-days. Assuming a fledging period of 15 days, nest success rate was estimated at 64.7 ± 6.5%.

For the 25 pairs that were monitored throughout the breeding season at Ixworth Thorpe an average of 1.7 clutches were laid per pair (range 1.5-1.8) producing an average of 1.5 (range 0.9-2.4) fledged chicks per pair (Table 3.8). At Deeping St Nicholas the 24 pairs monitored there produced 1.4 (range 1.0 - 1.6) clutches and 1.0 fledged young per pair. For the pairs that were monitored throughout the breeding season during 1998-2000 at both sites there was no significant interaction between year and site when considering the number of clutches ($F_{2,44} = 0.380$, $P > 0,05$) and young ($F_{2,44} = 1.00$, $P > 0.05$) produced per pair per year. After removing the non-significant interaction, the number of clutches and young produced per pair was not significantly different at the two sites (clutches: $F_{1,46} = 0.61$, $P > 0.05$; young: $F_{1,46} = 2.25$, $P > 0.05$) or during the three years of the study (clutches: $F_{2,46} = 0.58$, $P > 0.05$; young: $F_{2,46} = 1.80$, $P > 0.05$). Accordingly all data were combined and the 49 pairs monitored at both sites during all three years of the study produced averages of 1.6 ± 0.1 clutches and 1.3 ± 0.2 fledged young per pair (Table 3.8).

Table 3.6 Summary of nest outcome for Turtle Dove nests found at both sites, during 1998-2000. Numbers of nests in each category are given with % in parentheses. Data from Murton's study at Carlton is included for comparison.

	Abandoned before eggs	Abandoned after eggs laid	Adult predated	Predated	Weather	Fledged	Total
Ixworth Thorpe							
1998	1 (10 0)	1 (10.0)	0 (0.0)	1 (10.0)	0 (0.0)	7 (70.0)	10
1999	3 (16.7)	1 (5.5)	0 (0.0)	6 (33.3)	0 (0.0)	8 (44.4)	18
2000	2 (9.1)	1 (4.5)	0 (0.0)	11 (50.0)	0 (0.0)	8 (36.4)	22
All years	6 (12.0)	3 (6.0)	0 (0.0)	18 (50.0)	0 (0.0)	23 (36.4)	50
Deeping St. Nicholas							
1998	3 (15.7)	2 (10.5)	0 (0.0)	4 (21.1)	1 (5.3)	9 (47.4)	19
1999	10 (34.5)	3 (10.4)	0 (0.0)	9 (31.1)	0 (0.0)	7 (24.2)	29
2000	8 (17.8)	9 (20.0)	1 (1.1)	12 (26.7)	0 (0.0)	15 (33.4)	45
All years	21 (22.6)	14 (15.1)	1 (1.1)	25 (26.8)	1 (1.1)	31 (33.3)	93
Both sites all years	27 (18.8)	17 (11.8)	1 (0.7)	43 (30.1)	1 (0.7)	54 (37.7)	143
Nests with eggs	N/a	17 (14.7)	1 (0.9)	43 (37.1)	1 (0.9)	54 (46.6)	116
Carlton data (1960s)	N/a	6%	0%	56%	0%	38%	

Table 3.7a Calculations of nest success rate (Mayfield) during the incubation period at Ixworth Thorpe and Deeping St Nicholas, 1998-2000

	1998	1999	2000	All years
Incubation period (14 days)				
Ixworth Thorpe				
Nests (no. failed)	6 (1)	14 (5)	18 (9)	38 (15)
Observation days	77	104	185	366
Daily survival rate ± s.e.	0.987 ± 0.013	0.952 ± 0.021	0.951 ± 0.016	0.959 ± 0.010
Nest success rate (%) ± s.e.	83.3 ± 15.2	50.2 ± 15.5	49.7 ± 11.6	55.7 ± 8.4
Deeping St Nicholas				
Nests (no. failed)	8 (2)	14 (7)	28 (10)	50 (19)
Observation days	49	126	228	403
Daily survival rate ± s.e.	0.959 ± 0.028	0.944 ± 0.020	0.956 ± 0.014	0.953 ± 0.011
Nest success rate (%) ± s.e.	55.8 ± 23.1	44.9 ± 13.589	53.4 ± 10.6	50.8 ± 7.9
Both sites				
Nests (no. failed)	14 (3)	28 (12)	46 (19)	88 (34)
Observation days	126	230	413	769
Daily survival rate ± s.e.	0.976 ± 0.014	0.948 ± 0.015	0.954 ± 0.010	0.956 ± 0.007
Nest success rate (%) ± s.e.	71.4 ± 13.9	47.2 ± 10.2	51.7 ± 7.8	53.1 ± 5.7

Table 3.7b Calculations of nest success rate (Mayfield) during the brood-rearing period at Ixworth Thorpe and Deeping St Nicholas, 1998-2000

	1998	1999	2000	All years
Brood-rearing period (15 days)				
Ixworth Thorpe				
Nests (no. failed)	6 (1)	10 (2)	10 (2)	26 (5)
Observation days	53	111	129	293
Daily survival rate ± s.e.	0.981 ± 0.019	0.982 ± 0.013	0.984 ± 0.011	0.983 ± 0.008
Nest success rate (%) ± s.e.	75.2 ± 12.5	76.2 ± 14.7	79.1 ± 13.1	77.3 ± 8.9
Deeping St Nicholas				
Nests (no. failed)	8 (2)	9 (3)	21 (9)	38 (14)
Observation days	82	98	198	372
Daily survival rate ± s.e.	0.976 ± 0.017	0.969 ± 0.017	0.955 ± 0.015	0.962 ± 0.010
Nest success rate (%) ± s.e.	69.1 ± 18.1	62.7.2 ± 16.9	49.7 ± 11.6	56.3 ± 8.6
Both sites				
Nests (no. failed)	14 (3)	19 (5)	31 (11)	54 (19)
Observation days	135	209	327	665
Daily survival rate ± s.e.	0.978 ± 0.013	0.976 ± 0.011	0.966 ± 0.010	0.971 ± 0.006
Nest success rate (%) ± s.e.	71.4 ± 13.9	69.5 ± 11.3	59.8 ± 9.3	64.7 ± 6.5

Table 3.8 Summary of breeding success based on all nests found with eggs or nestlings at both study sites during 1998-2000 and those pairs which were monitored throughout the breeding season and for which all nesting attempts were known

	Sample size (nests)	Hatching success	Fledging success	Pairs monitored throughout breeding season	Clutches/ pair	Chicks fledged/pair
Ixworth Thorpe						
1998	9	88.8%	87.5%	5	1.6±0.2	2.4±0.7
1999	15	73.3%	72.7%	9	1.5±0.2	1.7±0.4
2000	20	47.3%	88.8%	11	1.8±0.3	0.9±0.3
All years	44	69.1%	78.2%	25	1.7±0.2	1.5±0.2
Deeping St. Nicholas						
1998	16	80.0%	75.0%	5	1.0±0.3	1.0±0.7
1999	19	66.6%	50.0%	8	1.6±0.5	1.0±0.5
2000	37	69.4%	60.0%	11	1.5±0.3	0.9±0.3
All years	72	70.3%	60.0%	24	1.4±0.2	1.0±0.3
Both sites all years	116	69.8%	79.4%	49	1.6±0.1	1.3±0.2

3.4.7 Finding missed nests

At Ixworth Thorpe, three missed nests were found during searches after leaf fall in 1999 and 1 in 2000. All of these nests were located in territories in which no nests were found during the breeding season, but only one of the nests found in 1999 appeared to have successfully fledged young. No missed nests were located at Deeping St Nicholas in 1999 and one possible nest was located in 2000. No further nests were found despite extensive searching. Assuming all nests were located (both during and after the breeding season), nest-searching efficiency during the breeding season was about 90%. However, this is likely to be an overestimate as, based on these figures, the implication is that only 50% of the territorial pairs attempted to breed. It is likely that active nests that were easy to find and those of radio-tagged birds were located during the breeding season, and nests that were not found during the breeding season and were also missed after leaf fall were located in habitats that made nest searching difficult.

3.4.8 Natal philopatry

During the course of this study 103 adult Turtle Doves were caught and fitted with metal rings and in 12 cases with additional colour rings. Sixty-five nestlings were also ringed with a metal and two colour rings. Only one bird with colour rings was resighted during the following years, at Deeping St Nicholas. That was a bird originally caught as an adult and ringed in 1996 during the pilot study and resighted in 1998, only about 500 m from the ringing site. One bird originally caught as an adult in 1998, ringed with a metal ring and fitted with a radio was re-caught in 2000.

3.5 Comparison with data collected in the 1960s

During the period 1960-62 and 1966 Murton studied the outcome of 72 nesting attempts made by 24 pairs of Turtle Doves. In addition, Murton carried out analysis of 569 BTO nest record cards collected up until 1966.

The results obtained by this study regarding nest site selection were in accordance with those recorded by Murton. The preferred nesting habitat identified by the nest record cards was the same, being farmland and scrub (often on farmland) and deciduous woodland edge. As in this study the majority of nests were found in hawthorn and to a lesser extent, elder. Nest height was similar, with Murton's mean nest height being 2.3 m.

At Carlton, laying was not recorded until the second half of May and continued until late August (Figure 3.3). A peak occurred in late June followed by a second peak in early August. The data from this study followed a significantly different pattern to that recorded by Murton, showing that Turtle Doves had a reduced breeding season that lacked Murton's August peak ($\chi^2_6 = 13.63, P = 0.034$). In the 1960s, 24% of nesting attempts were started in August compared to 5% during this study.

Using the data collected at Carlton, Murton records that generally each pair studied produced three clutches of two eggs. Clutch sizes from the nest record cards (range 1.85 to 1.97) varied slightly with season and increased as the season progressed. Murton did not measure incubation and nestling period but reports that data from the nest record cards generally agreed with earlier published values of 13.5 days for incubation and about 20 days for brood-rearing. These values are in general agreement with those observed during this study.

Assuming that each nest at Carlton contained two eggs, the overall nest outcome (based on the fate of individual nests) was significantly different between the two studies ($\chi^2_3 = 8.84, P = 0.032$). During Murton's study 6% of nests were abandoned, 56% of nests were lost to predation and 38% fledged young, compared with 15%, 37% and 47% in this study (ensuring comparability by only using nests that contained eggs in Table 3.6). An examination of the individual components of the χ^2 test showed that the observed values for abandonment and predation differed from expected, but those for nesting success did not. Using data from Carlton, Murton calculated hatching and fledgling success by following the fate of individual eggs and nestlings. A similar approach was undertaken using data collected by this study. The results from both datasets are summarised in Table 3.9. During this study hatching success (number of eggs laid that actually hatched) was significantly higher, but fledging success (number of eggs hatching that actually produced fledged young) was slightly lower. In general terms, breeding success (proportion of initiated clutches that produce fledged young) appears to be the same today as in the 1960s. However the number of clutches laid and the number of chicks fledged per pair were significantly lower today than during Murton's study, having been almost halved (Table 3.9).

Table 3.9 Comparison of breeding success for nests found during Murton's study (1960s) and this study (1990s). Only nests found at the egg and nestling stage in the 1990s are included, to ensure compatibility.

	1960s	**1990s**	**z-test**
Sample size (nests)	72	116	
Hatching success	46 ± 6%	63 ± 5%	4.59, $P < 0.01$
Fledging success	84 ± 6%	69 ± 6%	0.26, n.s.
Overall nesting success	38 ± 6%	43 ± 5%	1.07, n.s.
Clutches/pair	2.9 ± 0.1	1.6 ± 0.1	8.36, $P < 0.01$
Chicks fledged/pair	2.1 ± 0.3	1.3 ± 0.2	2.24, $P < 0.05$

3.5.1 The implication of changes in breeding success on the population size

To investigate the population consequences of the reduction in the number of young fledged per pair, it is possible to estimate the rate of annual population change in the 1960s and today. In the 1960s, 100 pairs of Turtle Doves produced 210 young. Assuming that the adult and juvenile survival rate estimates of 50%, calculated by Murton in the 1960s, still hold, the number of pairs returning to breed in the following year was 102.5 ((100 * 0.5) + ((210 * 0.5) / 2) = 102.5). This implies that the rate of annual population change then was +2.5%. Today 100 pairs produce 130 young, of which, using Murton's estimate of survival, 82.5 pairs return to breed in the following year ((100 * 0.5) + ((130 * 0.5) / 2) = 82.5). This implies that the rate of annual population change today is -17.5%. The British Trust for Ornithology gives an average annual rate for national population change of –6.1%, over the period

1973-1998 (Baillie *et al.* 2001). Although the calculation used is basic, if the changes in productivity observed are occurring nationally they more than explain the observed declines in the UK breeding population of the Turtle Dove.

3.6 Discussion

Turtle dove density at the Ixworth Thorpe study site was 4.4 territories per km^2 and 0.4 territories per km^2 at Deeping St Nicholas. Previously reported densities for Turtle Doves in Britain are 1.4 pairs per km^2 in farmland and 2.2 pairs per km^2 in woodland during the period 1968-1972 (Sharrock 1976) and 0.6 and 2.6 pairs per km^2 in farmland and woodland respectively during the period 1988-1991 (Gibbons *et al.* 1993). The 1968-1972 values were produced during the period when Turtle Dove abundance and distribution were at their highest in the UK and the 1988-91 values after the start of the species' decline. Other studies across the species' breeding range have shown that Turtle Dove density varies from 1.4-30.0 pairs per km^2 in a range of wooded and farmland habitats (Holzwarth 1971, Kraus *et al.* 1972, Bijlsma 1985, Genard 1989, Dias & Fontoura 1996). This makes the density recorded at Ixworth Thorpe about average in a European context and above average in a British context. The Deeping St Nicholas densities were well below the European average and below the British average farmland density.

The results from this study show the importance of the non-cropped habitats in terms of nesting territory and nest-site selection of the Turtle Dove. At both study sites Turtle Doves established their nesting territories in areas containing woodland edge, scrub, hedges and small gardens. This is dictated by the species' need to nest in shrubs and to a lesser extent, trees. At Ixworth Thorpe numerous woodlands and areas of scrub have been planted and managed for game and these were the predominant nest locations, with hedges being less favoured. At Deeping St Nicholas, where only a few woodlands are present (less than 1% of land cover), other habitat types such as scrub around farm buildings, isolated bushes and hedges were used for nesting. It is likely that the absence of suitable nesting habitat around the Deeping St Nicholas area is one of the main causes of the comparatively low density of breeding Turtle Doves recorded there.

The peak period of Turtle Dove territorial activity appears to be early June, when the maximum number of apparently occupied territories was recorded. The number of territories recorded at both study sites declined steadily through the breeding season and apparent occupancy of individual territories was not constant. This may have been due to the detectability of territorial behaviour, but most likely reflects the movement of territorial males. Previous studies have indicated that Turtle Doves usually start breeding in early to mid-May and continue through to the end of August. However, this study suggests that Turtle Doves restrict their breeding activities to a shorter season, by initiating fewer clutches in August.

The information collected on general breeding biology was similar to that documented in the literature (Holzwarth 1971, Kraus *et al.* 1972, Kotov 1974, Cederwell 1978, Pikula & Beklova 1984, Bijlsma 1985, Genard 1989, Peiró 1990, Nankinov 1994a, Nankinov 1994b, Dias & Fontoura 1996, Dias *et al.* 1996). The use of thorny bushes as nesting sites, a nest height of around 2 m and a clutch size of two has been widely documented. An incubation period of about 14 days and a nestling period of about 15 days as observed in the present study is consistent with the values previously reported.

Where the results of the current study differ consistently from those of other studies is in the reduced number of successful nesting attempts and its consequent impact on the number of young fledged per pair during the breeding season. Throughout this study, which observed the complete nesting histories of 49 pairs, only ten (20%) laid a further clutch after successfully raising an earlier one. Obviously some nests may have been missed and the actual number of pairs that laid a further clutch may be slightly higher, but it is well below the value of other studies (Murton 1968). As Murton was primarily studying Woodpigeons he may have overlooked Turtle Dove nests that were predated soon after eggs were laid, so it is possible that Murton's estimate of clutches per pair may be an under-estimate. The major consequence of the reduction in the number of nesting attempts is the reduction in the number of young fledged per pair per annum. The study conducted by Murton is the only one to report the number of young fledged per pair, giving a value of 2.8 per pair per annum; however a close examination of his data suggests that a typographical error was made and that the actual value was 2.1. This lower value is still significantly higher than that recorded by this study. The implication of this reduction in Turtle Dove productivity suggests that the 2.5% annual increase in the breeding population (consistent with the national population trend) at Murton's time has become a population decrease of 17.5% per annum today.

Natal philopatry appears to be very low, as only two birds (both originally caught as adults) were resighted or recaught. Whilst it is possible that ringed birds may have been overlooked, a lot of effort was put into checking the birds for rings. Given the Turtle Doves' habit of feeding on bare ground, I am confident that very few ringed birds were missed.

CHAPTER 4

FORAGING BEHAVIOUR AND DIET

4.1 Introduction

The diet and food availability of individual birds can have important consequences for breeding performance and survival (Newton 1998). For some bird species breeding performance is cyclic, being linked directly to annual variations in food availability (e.g. Rough-legged Buzzards (Hagen 1969) and most other birds of Prey (Newton 1979)). For these species the number of young produced can be between three to six-fold higher in years of good prey abundance compared to poor years (Newton 1979). Even species that have very little annual variation in breeding performance can suffer catastrophic years after a sudden reduction in food availability (e.g. Arctic Skua (Philips *et al.* 1996) & Shag (Aebischer 1986)). It is therefore apparent that food limitation during the breeding season can have serious detrimental effects on reproductive output (Martin 1987). Long-term food shortage may reduce population size through reduced breeding performance and it is likely that this may occur over a long time-scale (Newton 1998). The decline of farmland birds throughout Europe (Fuller *et al.* 1995, Heath *et al.* 2000) is likely to be linked to the massive reduction in food availability brought about by agricultural intensification (Chamberlain *et al.* 2000). In this Chapter the diet and foraging behaviour of Turtle Doves is assessed and compared with that of the 1960s in order to understand its role in the decline of the species.

The habitat requirements of Turtle Doves away from the nest site have been little studied. The only detailed work was carried out by Murton *et al.* (1964), and this is discussed later in this section. In general landscape terms Turtle Doves are known to occur in a range of open lowland habitats which are interspersed with hedges, scrub and small woods (Kraus *et al.* 1972, Kotov 1974, Bijlsma 1985, Peiró 1990, Dias & Fontoura 1996). Turtle doves avoid certain very open areas, such as heathland and large tracks of extensive woodland, but they do occur in young plantations and managed (thinned) woodland (Kraus *et al.* 1972, Kotov 1974, Genard 1989). Turtle doves appear to favour warm areas, being found within the 17°C average maximum daily July temperature isotherm in Germany (Kraus *et al.* 1972) and the 19°C isotherm in Britain (Norris 1960).

A number of dietary studies have been undertaken throughout the Turtle Dove's breeding range, based mainly on the analysis of crop and gizzard contents from birds shot or killed accidentally (Murton *et al.* 1964, Garzón 1974, Kiss *et al.* 1978, Jimenez *et al.* 1992, Dias & Fontoura 1996). In almost all cases the seeds from wild plants (weeds) were identified as the main component of the bird's diet, with the seeds of locally cultivated crops making up the remainder. Many studies found that the seeds from Common Fumitory and Common Chickweed formed an important part of the diet. In areas where the cultivated seeds were taken this usually coincided with harvest time.

4.2 Methods

4.2.1 Foraging behaviour

The foraging behaviour of Turtle Doves was assessed through the relocation of birds fitted with radio transmitters and through the observation of feeding birds. A protocol for obtaining fixes of radio-tagged birds at Ixworth Thorpe was established whereby days were grouped into five-day periods and further divided into 3-hour intervals from 0400 to 2200 (i.e. 04-07, 07-10, etc). Within each 5-day period attempts were made to obtain 3 fixes within each 3-hour period. A fix was derived from an approximate triangulation and was confirmed visually. At Deeping St Nicholas, where birds were much more widely distributed, the above protocol was followed as closely as possible. All fixes were plotted onto maps whilst in the field.

The locations of all fixes were transferred onto digitised maps of the appropriate study site stored within the mappable database system MapInfo 5.5 (MapInfo Corp. 1999). Home ranges were evaluated using minimum convex polygons (MCPs) drawn around all the plotted fixes for birds with 10 or more relocations (Kenward 1987). The area of the MCPs, and the proportions of each habitat within them, were determined using the mapping software.

4.2.2 Foraging distance

Foraging distance was measured for all radio-tagged doves with 10 or more relocations. Foraging distance was measured in a straight line from a mid-point in the doves' territory to the point of relocation. The territory mid-point was either the nest for birds that had only had one nesting attempt, or a point mid-way between all nests. All relocations away from the nest were regarded as foraging trips, irrespective of whether feeding behaviour was recorded or not. All measurements were made using the mapping software.

4.2.3 Monitoring feeding sites

Whenever a Turtle Dove was seen feeding, it was observed to ascertain the precise area and its choice of foodstuff. Once certain of its feeding location and after the bird had departed, the following variables were measured: plant species present within an area of 1 m^2 centred on the dove's location, ground cover of each species, which plants were seeding or in flower, and vegetation height. The proportion of potential seedheads at each of five stages (bud, flower, immature seedhead, ripe seedhead and old seedhead) was estimated roughly by eye. The presence of fallen seed was also noted.

4.2.4 Collecting faecal material

Turtle dove faecal samples were collected when seen to be deposited by adults, from birds being handled and from nests. After each breeding attempt had finished, all nests were collected, as they were encrusted with droppings. All faecal samples were air-dried and stored in sealed plastic bags.

4.2.5 Faecal analysis

Each faecal sample was soaked in water for 18 hours and sieved through a 180-micron gauze to remove unidentifiable material. The filtered samples were examined under a binocular microscope and identified by comparison to reference material (Flood & Gates 1996). The proportion of each species of seed within each sample was estimated to the nearest 5%, using a grid marked with 1-cm squares, based on the percentage cover by area of seed testa and membranes. Each sample collected from an adult or a nestling was treated separately; for an encrusted nest a sample consisted of 10 droppings (representing 25-100% of material present).

4.2.6 Evaluation of faecal analysis

The accuracy of the results obtained from the identification of seed material within sieved faecal samples was evaluated in two ways. Firstly, the results obtained were compared with the crop contents from dead wild adults found during the project and, secondly, by comparison with faecal material obtained from captive birds. Four adults were recovered freshly killed by predators from the study sites. The crops of these dead birds were removed and the seeds within them identified. The proportion of each species of seed within each sample was estimated to the nearest 5%, based on the percentage cover by area of seed surface.

Data for a pair of captive Turtle Doves were provided by a registered aviculturalist. He provided a sample of the food fed to the doves and a sample of faecal material. The sample of food, which weighted approximately 80 g, was divided into three equal samples and the proportions of each seed type within them were estimated. The sample of faecal material from the captive birds comprised 34 droppings (approximately 55 g) and was divided into three samples, each containing 10 droppings. These were prepared and analysed as described in section 4.2.5.

4.3 Statistical analysis

Initially, habitat utilisation by the tagged Turtle Doves was compared between Ixworth Thorpe and Deeping St Nicholas using compositional analysis (Aebischer *et al.* 1993a, b). It was then compared with random use of available habitats at two levels. First, the proportional area of habitats contained within the MCPs was compared with that available within the entire study site (Aebischer *et al.* 1993a,b). Second, the proportions of habitat within a 50-m radius of all fixes combined were compared to those available within the relevant MCP. The choice of a 50-m radius was partly arbitrary but was thought to be representative of the actual habitats being utilised, rather than simply being flown over, by a Turtle Dove at the time of one radio-location.

For the analysis of habitats used as feeding sites in relation to study site and season, the data from the "manure heap" category (as used in Table 4.5) were combined with that in the "other" category, to overcome the problem of sparse data.

To check if dietary composition estimated from faecal material gave a good representation of Turtle Dove diet the method was tested in two ways. First, the dietary composition of wild adult birds obtained from faecal analysis was compared with that obtained from the crop contents of adults found predated, using compositional analysis (Aebischer *et al.* 1993a, b). For each wild adult bird, the diet was categorised into four seed types, these were (1) Wheat, (2) Oil-seed Rape, (3) other cultivated seeds and (4) weed seeds. The proportions in each category were transformed to three logratios, using the fourth category as the denominator in the transformation. Zero proportions were replaced by 0.001 to allow logarithmic transformation. Second, the composition of seeds fed to captive birds was compared with the composition of seeds identified in their faecal material, using the same approach. In this case the diet was categorised into five seed types, (1) Canary Millet, (2) other Millet, (3) brassicas, (4) Wheat and (5) others. The fifth category was used as the denominator.

4.4 Results

4.4.1 Home range

At neither Ixworth Thorpe nor Deeping St Nicholas was there a significant relationship between home range area and number of fixes ($r_{14} = 0.356, P > 0.05, r_8 = 0.579, P > 0.05$ respectively). The home ranges for the entire breeding season ranged from 0.3-367.5 ha (mean 83.5 ± 23.9) at Ixworth Thorpe and 36.4-1130 ha (mean 497.3 ± 222.5) at Deeping St Nicholas, with those at Deeping St Nicholas being significantly larger than at Ixworth Thorpe ($t_{24} = 3.20, P = 0.004$) (Table 4.1). The habitat composition of the home ranges and within 50 m of each radio location is given in Table 4.2 and the average over 1999 and 2000 displayed in Figure 4.1.

There was no significant difference in the use of habitat at the two sites ($\Lambda = 0.753$, $F_{4,20} = 1.64, P = 0.204$). To increase the sample size and power of the analysis, the habitat data from each site were pooled. Compositional analysis applied to data from 26 radio-tagged Turtle Doves showed that habitat use within the MCP ranges differed significantly from random ($\Lambda = 0.614$, $F_{4,21} = 3.28$, $P = 0.031$). Thus the home ranges of Turtle Doves were not established at random on the study site. The ranking matrix (Table 4.3) indicated that woodland was the habitat most used relative to availability (rank 4), and that cereals was least used relative to availability.

The use of habitat within 50 m of the radiolocations did not differ significantly from the habitat available within the MCP ranges ($\Lambda = 0.730$, $F_{4,21} = 1.942$, $P = 0.141$).

Table 4.1 Home-range sizes and foraging distances (mean and max) of radiotagged Turtle Doves at Ixworth Thorpe and Deeping St Nicholas during 1999 - 2000 (only birds with more than 10 relocations are shown)

Radio frequency	Year	Number of radiolocations	Area (ha)	Mean foraging distance (m)	Maximum foraging distance (m)
Ixworth Thorpe					
46	1999	10	0.3	38	86
205	1999	48	143.2	819	2093
286	1999	58	133.7	765	2390
324	1999	10	87.1	653	1722
441	1999	53	367.5	716	1962
483	1999	54	11.5	207	588
750	1999	50	10.7	155	526
302	2000	37	85.7	462	2153
661	2000	32	33.1	302	704
712	2000	29	72.7	480	2060
743	2000	37	54.5	495	2070
789	2000	29	213.2	634	2131
801	2000	25	6.8	151	298
823	2000	35	46.6	197	807
930	2000	15	8.19	153	439
972	2000	39	60.6	725	1882
Mean			83.5	504	1369
s.e.			24.0	27	206
Deeping St. Nicholas					
24	1999	30	142.5	369	5899
64	1999	47	904.2	2623	3911
147	1999	79	904.4	919	3005
384	1999	86	1130	3145	4081
504	1999	17	36.4	1596	2476
203	2000	30	118.5	343	2368
781	2000	41	50.5	626	2987
831	2000	40	265.4	954	6204
923	2000	35	1331.4	900	10143
941	2000	49	89.9	2106	3737
Mean			497.3	1567	4481
s.e.			160.8	72	753

Table 4.2 Habitat availability (% of study site) at each study site during 1999-2000 and habitat composition (% ± s.e.) within Turtle Dove MCP home ranges and within 50 m of radiolocations (n = number of radio-tagged birds)

	Cereals	**Break crops**	**Grass**	**Woodland**	**Other**
Ixworth Thorpe 1999 (n=7)					
Study Site	26.0	37.0	16.7	10.5	9.2
MCP	15.3 ± 5.3	33.2 ± 10.3	18.9 ± 6.3	18.5 ± 3.9	14.4 ± 5.4
Radiolocations	6.1 ± 3.1	29.0 ± 2.5	19.8 ± 4.6	29.3 ± 4.2	15.7 ± 3.5
2000 (n=9)					
Study Site	33.2	30.3	13.8	11.8	10.8
MCP	17.1 ± 4.4	24.4 ± 6.1	17.8 ± 7.1	22.0 ± 7.6	18.7 ± 6.5
Radiolocations	8.3 ± 2.6	12.6 ± 1.8	23.3 ± 7.3	31.7 ± 6.2	24.2 ± 5.8
Deeping St. Nicholas 1999 (n=5)					
Study Site	40.2	41.0	7.4	0.7	11.0
MCP	27.7 ± 7.8	52.8 ± 9.3	5.0 ± 1.4	1.0 ± 0.3	13.5 ± 2.4
Radiolocations	5.3 ± 2.3	39.6 ± 9.1	19.4 ± 7.5	8.4 ± 3.4	27.4 ± 5.2
2000 (n=5)					
Study Site	52.8	30.7	6.7	0.8	9.1
MCP	58.4 ± 4.9	14.3 ± 4.7	6.2 ± 1.7	1.5 ± 0.2	20.3 ± 2.4
Radiolocations	24.9 ± 9.6	9.6 ± 1.9	10.2 ± 5.4	6.5 ± 4.9	48.9 ± 8.6

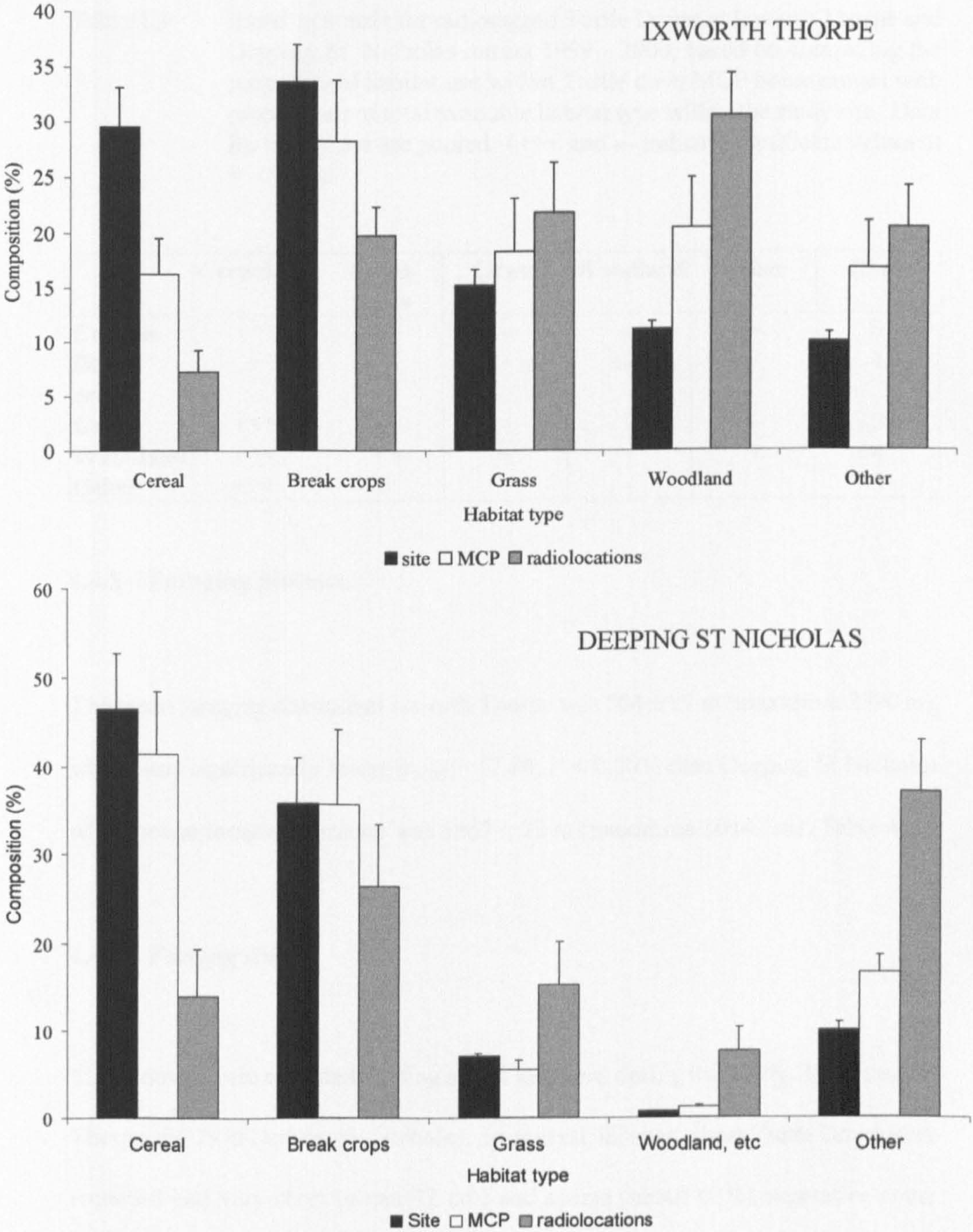


Figure 4.1 Mean habitat availability at Ixworth Thorpe (n = 16) and Deeping St Nicholas (n = 10) and mean habitat utilisation within Turtle Dove MCP home ranges and within a 50-m radius of radiolocations, 1999-2000. The error bars represent 1 s.e.

Table 4.3 Ranking matrix for radiotagged Turtle Doves at Ixworth Thorpe and Deeping St. Nicholas during 1999 - 2000, based on comparing the proportional habitat use within Turtle dove MCP home ranges with proportions of total available habitat type within the study site. Data for both years are pooled. (+++ and --- indicate significant values at $P < 0.05$).

	Cereals	Break crops	Grass	Woodland	Other	Rank
Cereals		-	---	---	---	0
Break crops	+		-	---	-	1
Grass	+++	+		-	-	2
Woodland	+++	+++	+		+	4
Other	+++	+	+	-		3

4.4.2 Foraging distance

The mean foraging distance at Ixworth Thorpe was 504 ± 27 m (maximum 2390 m), which was significantly lower ($t_{1023} = 12.88$, $P < 0.001$) than Deeping St Nicholas where mean foraging distance was 1567 ± 72 m (maximum 10142 m) (Table 4.1).

4.4.3 Feeding sites

Turtle doves were recorded feeding at 114 locations during this study, 35 at Ixworth Thorpe and 79 at Deeping St Nicholas. In general, all sites where Turtle Doves were recorded had very short (about 12 cm) and sparse (about 40%) vegetative cover (Table 4.4). Vegetation height at the two sites did not differ significantly in 1998 or 1999 but was significantly different in 2000 ($t_{41} = 2.42$, $P = 0.02$). Overall, at Ixworth Thorpe vegetation height was similar in all years, but at Deeping St Nicholas vegetation height varied significantly between years ($F_{2,76}$ = 18.75, P < 0.01). Vegetation cover at the feeding sites did not differ between study sites (two-way ANOVA on logit-transformed cover $F_{1,110} = 3.73$), but differed significantly between years, ($F_{2,110} = 4.65, P = 0.011$).

Table 4.4 Mean vegetation cover (%) and vegetation height (cm) at Turtle dove feeding sites at Ixworth Thorpe and Deeping St Nicholas during 1998-2000. Means are given ± 1 s.e.

	No. of observations	Vegetation cover (%)	Vegetation height (cm)
Ixworth Thorpe			
1998	18	22.2 ± 7.7	5.4 ± 1.3
1999	8	29.4 ± 11.2	15.1 ± 6.8
2000	10	36.0 ± 10.9	9.5 ± 2.7
All years	36	27.6 ± 5.4	8.7 ± 1.8
Deeping St Nicholas			
1998	25	31.2 ± 6.9	5.6 ± 1.2
1999	21	46.2 ± 7.1	5.7 ± 1.6
2000	33	61.6 ± 6.5	26.6 ± 3.7
All years	79	47.9 ± 4.2	14.4 ± 2.1
Both sites			
All years	115	41.6 ± 3.4	12.6 ± 1.5

Feeding birds were recorded at a range of different habitat types, but principally they used those categorised as "other", which included spilt grain in farm yards, animal feed and non-arable habitats (Table 4.5). In almost all cases the birds recorded on crops were feeding on the weed strip around the edge of fields and on stubbles after harvest. Birds recorded on road verges were assumed to be feeding on spilt grain or collecting grit. Although Turtle Doves were recorded on all habitat categories at both sites, habitat use differed between the two sites ($\chi^2_5 = 14.93, P = 0.011$). At Ixworth Thorpe Turtle Doves made greater use of animal food and less use of crops, whereas at Deeping St Nicholas crops were used more.

Table 4.5 Frequency (%) of feeding observations of Turtle Doves in different habitat types at Ixworth Thorpe and Deeping St. Nicholas, 1998-2000. "Other" includes farmyards, rough ground, bare earth, concrete pads, dumped grain and open grain stores.

	No of observations	Cereals	Break crops	Grass	Manure heaps	Animal feed	Roadside verges	Other
Ixworth Thorpe								
1998	19	21.1	0.0	5.3	5.3	21.1	15.8	31.6
1999	8	0.0	50.0	0.0	12.5	0.0	12.5	25.0
2000	13	0.0	23.1	0.0	0.0	23.1	7.7	46.2
Early	26	0.0	15.4	3.8	3.8	19.2	15.4	42.3
Late	14	28.6	21.4	0.0	7.1	14.3	7.1	21.4
Overall	40	10.0	17.5	2.5	5.0	17.5	12.5	35.0
Deeping St Nicholas								
1998	31	19.4	12.9	0.0	0.0	3.2	16.1	48.4
1999	21	0.0	42.9	14.3	0.0	0.0	9.5	33.3
2000	33	18.2	33.3	15.2	0.0	0.0	6.1	27.3
Early	33	0.0	27.3	6.1	0.0	0.0	15.2	51.5
Late	52	23.1	28.8	11.5	0.0	1.9	7.7	26.9
Overall	85	14.1	28.2	9.4	0.0	1.2	10.6	36.5
Both sites								
Overall	125	12.8	24.8	7.2	1.6	6.4	11.2	36.0

In all three years the feeding behaviour of Turtle Doves followed a similar pattern, with habitat use early in the season (May and June) being significantly different from that later (July and August) ($\chi^2_5 = 21.70, P < 0.001$). Early in the breeding season Turtle Doves used farm yards when grain was being moved (and spilt) from the storage barns. During early June, they were seen away from farm yards and were recorded in lower numbers (usually singles or pairs). From early June through to early August the doves were recorded almost exclusively on one or two specific feeding sites. At Ixworth Thorpe these were dumped grain and in 1999, an area of Rabbit-grazed and very weedy rape crop. About 30 birds were seen daily, representing about 65% of the local breeding population. At Deeping St Nicholas these sites were Daffodil fields. After the Daffodils died back in mid-April, the fields became colonised with a large number of weeds and supported about 50% of the breeding doves in the area. The doves stopped using the fields once they were sprayed with herbicide in early August. After the commencement of harvest (early August onwards) Turtle Doves were regularly recorded on wheat and rape stubbles.

4.4.4 Adult diet

Eighteen faecal samples were collected from adult Turtle Doves, 15 at Ixworth Thorpe and 3 at Deeping St Nicholas. The diet of these birds was entirely seeds and is summarised in Table 4.6. Cultivated seeds, principally wheat and oil-seed rape, formed 60% of the seeds taken, with the remainder being made up by a mixture of other weed species, mainly Common Fumitory, Knotgrass and Common Chickweed (Figure 4.2).

Table 4.6 Species composition (%) based on area of testa of seeds identified in adult Turtle Dove faecal samples collected at Ixworth Thorpe and Deeping St Nicholas during the 1998-2000 breeding seasons

	No. of birds	Wheat	Rape	Chickweed	Mignonette	Knotgrass	Redshank	Fumitory	Grass
Ixworth Thorpe									
1998	4	15.0	37.7	23.7	0.0	23.7	0.0	0.0	0.0
1999	8	58.7	16.8	11.2	11.8	0.0	0.6	0.0	0.7
2000	3	33.3	0.0	0.0	0.0	33.3	0.0	33.3	0.0
Mean	15	42.0	19.1	12.3	6.3	13.0	0.3	6.7	0.4
Deeping St Nicholas									
1998	1	10.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	2	17.5	17.5	0.0	0.0	0.0	0.0	65.0	0.0
Mean	3	15.0	41.7	0.0	0.0	0.0	0.0	43.3	0.0
Both sites	18	37.5	22.8	10.3	5.3	10.8	0.3	12.8	0.3

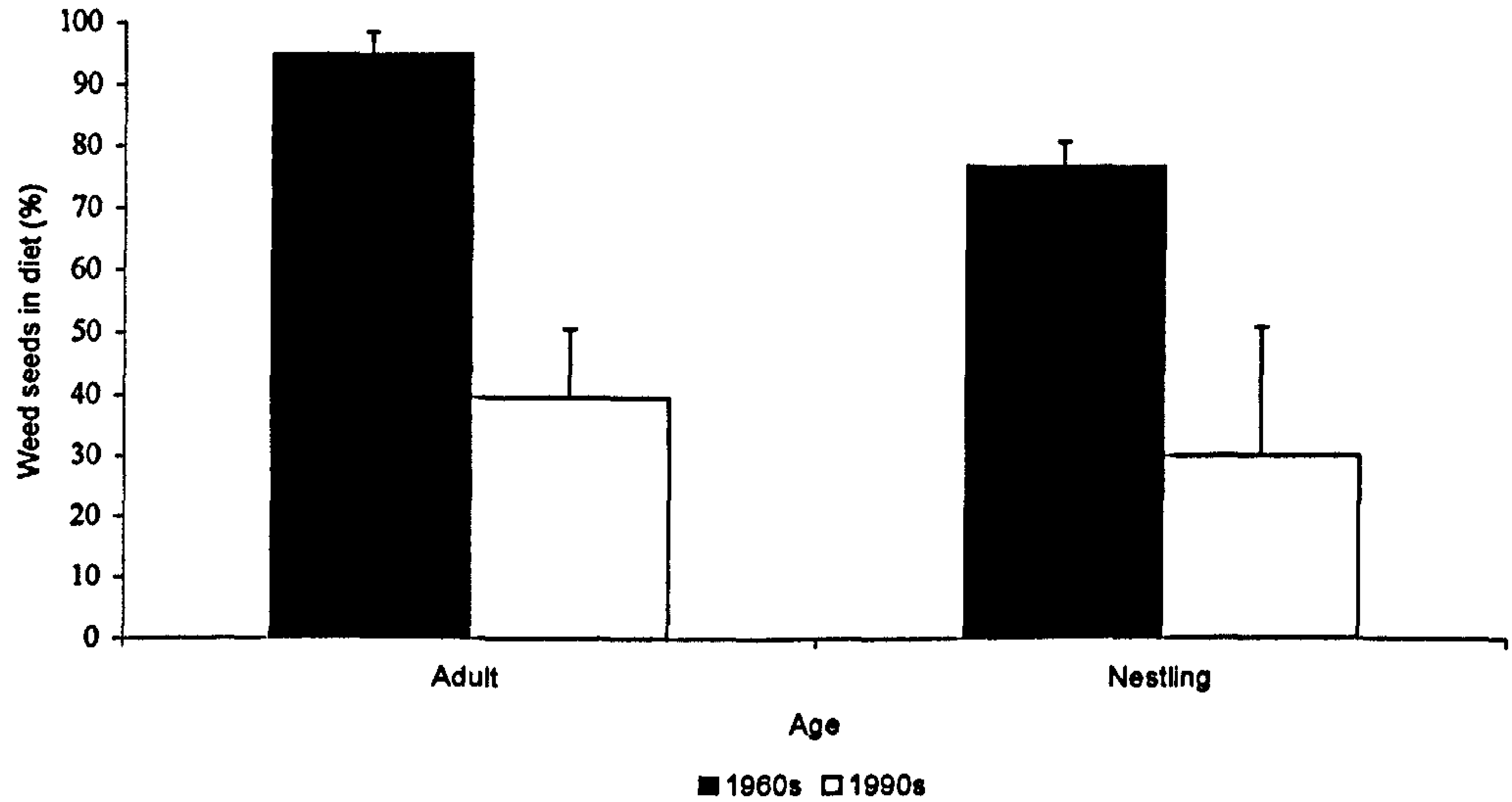


Figure 4.2 The percentage composition of the seeds from non-cultivated plants ("weeds") in the diet of Turtle Doves in the 1960s at Carlton and in the 1990s (1998-2000) at Ixworth Thorpe and Deeping St Nicholas. The error bars represent 1 s.e

4.4.5 Nestling diet

The faecal material from 53 nests was collected and analysed to assess nestling diet, 29 from Ixworth Thorpe and 24 from Deeping St Nicholas. The seeds from cultivated plants constituted 73% of the seeds eaten by nestlings at Ixworth Thorpe and 63% at Deeping St Nicholas (Table 4.7). The seeds from non-cultivated plants (weeds) comprised the remainder of the diet, mainly Field Pansy at Ixworth Thorpe and Common Fumitory at Deeping St Nicholas. There was a significant difference in the diets of doves at the two sites (two-way ANOVA on logit-transformed %: $F_{1,49} = 4.41$, $P = 0.041$) but there was no difference in the diet of the doves during the different years of the study ($F_{2,49} = 2.81$, $P = 0.070$).

Table 4.7 Species composition (%) based on area of testa of seeds identified in nestling Turtle Dove faecal samples collected at Ixworth Thorpe and Deeping St Nicholas during the 1998-2000 breeding seasons

	No. of nests	Wheat	Rape.	Field Pansy	Chickweed	Mignonette	Knotgrass	Redshank	Fumitory	Grasses	Orache	Nettle	Unknown weed
Ixworth Thorpe													
1998	8	49.4	48.2	0.0	0.2	2.5	0.0	0.2	0.0	0.0	0.0	0.0	0.0
1999	10	34.0	17.5	33.5	6.5	6.0	0.5	1.0	0.0	1.0	0.0	0.0	0.0
2000	11	41.8	32.7	1.8	5.0	2.3	0.0	7.7	6.8	0.1	0.0	0.9	0.0
Mean	29	41.2	31.7	12.2	4.2	3.6	0.2	3.3	2.6	0.4	0.0	0.3	0.0
Deeping St. Nicholas													
1998	4	47.5	42.5	0.0	5.0	2.5	0.0	2.5	0.0	0.0	0.0	0.0	0.0
1999	8	39.7	21.5	1.2	10.6	0.2	1.9	1.3	16.2	6.8	0.6	0.0	0.0
2000	12	22.0	33.3	0.0	1.2	0.0	0.0	3.3	39.2	2.1	0.0	0.0	0.1
Mean	24	32.2	30.9	0.4	5.0	0.5	0.6	2.5	25.0	3.3	0.2	0.0	0.1
Both sites	53	37.1	31.4	6.9	4.6	2.2	0.3	2.9	12.7	1.7	0.1	0.2	0.1

4.4.6 Evaluation of faecal analysis

The crop contents from the dead adult birds contained a similar mixture of cultivated and non-cultivated seeds as found in the adult faecal material. The composition of seeds within the crops did not differ from the composition of seeds identified in the faecal material ($\Lambda = 0.973$, $F_{3,18} = 0.169$, $P = 0.916$). The seed mixture fed to the captive Turtle Doves contained Canary Millet and Panicum Millet, Wheat, Oil-seed Rape, Hemp and small amounts of other seeds. The seeds identified in the captive-bird faecal material were representative of the food and did not differ significantly in composition ($\Lambda = 0.019$, $F_{4,1} = 14.22$, $P = 0.203$).

4.5 Comparison with data collected in the 1960s

4.5.1 Foraging behaviour

During the period 1958-1962, Murton *et al.* (1964) recorded 406 observations of feeding Turtle Doves at the Carlton study site. These data and the corresponding data collected by this study are summarised for early (April-June) and late (July-Sept) in the breeding season and are shown in Table 4.8. During Murton's study Turtle Doves were recorded almost exclusively on clover, trefoil and hay fields in the early part of the breeding season and to a much lesser extent on crops. In the late part of the season birds were recorded on arable fields, principally pea fields and harvested cereals. Murton *et al.* (1964) observed that the noticeable preference for pea fields was in fact for places where many weeds had grown. Within the harvested cereal fields Turtle Doves were recorded feeding on stooked wheat and on spilt grain within the stubbles.

Table 4.8 The habitat available and used by Turtle Doves at Carlton in the 1950/60s and at GCT study sites (early=April to June, late=July-September). The "others" category includes farm yards, gardens, etc.

	Habitat available (%)		Habitat used (%)			
	Murton study	GCT study	Murton study		GCT study	
			Early	Late	Early	Late
No. of observations			235	171	71	75
Crops (except peas)	66.0	82.0	5.5	51.0	18.3	46.6
Peas	0.2	7.0	0.0	30.0	2.8	0.0
Pasture	25	5.0	1.0	1.0	2.8	0.0
Clover ley, hay	3.4	3.0	87.0	6.0	0.0	0.0
Manure heaps	0.1	0.1	0.5	5.0	1.4	1.3
Roadside verges	1.0	1.0	2.0	2.0	9.8	5.3
Others	4.3	2.0	4.0	5.0	64.8	38.6

During this study the foraging behaviour of Turtle Doves in both the early and late part of the breeding season differed significantly from that recorded by Murton (early: $\chi^2_4 = 181.0, P < 0.001$; late: $\chi^2_4 = 18.2, P = 0.001$). Turtle doves were more dependent on non-cropped habitats, such as farmyards and livestock feeding areas where they fed on spilt grain, and this was particularly evident in the early part of the breeding season. In contrast to Murton's findings no Turtle Doves were recorded on clover, ley or hay fields. In the 1960s/70s clover leys were rich in weed seeds and were important feeding areas for a range of species (Green 1978). However, clover leys only constituted 0.2% of the land area during this study, with the remainder of the clover, ley and hay grouping in Table 4.8 being made up of herbicide treated hay fields, which were likely to have contained far fewer weeds than the 1960s clover leys. In the later half of the breeding season Turtle Doves made similar use of crops, mainly cereal and rape stubbles, but still used other habitats containing spilt grain.

4.5.2 Diet

Murton assessed Turtle Dove diet through the analysis of crop contents from 41 adult birds and 5 nestlings killed accidentally (Murton *et al.* 1964), whereas this study assessed diet primarily through the analysis of faecal material.

Murton reported that the diet of adult Turtle Doves consisted of over 95% weed seeds, mainly fumitory, which was significantly higher than the 40% recorded by this study ($t_{57} = 3.71$, $P < 0.01$) (Figure 4.2). Similarly the diet of nestlings contained about 75% weed seeds during the 1960s, which is significantly higher than the 31% recorded in this study ($t_{61} = 2.76$, $P < 0.01$).

4.5.3 The consequence of diet change on breeding performance

To investigate the possible consequences of diet change on breeding performance, chick condition (weight) and nesting success during the brood-rearing period were examined in relation to the proportion of weed seed in the diet. The mean weight and mean tarsus length of broods were positively related according to the equation ln(mean weight) = 2.339 + 0.103 x ln(tarsus length) ($r_{33} = 0.918$ $P < 0.001$). This confirmed that mean brood weights needed to be adjusted for tarsus length before further analysis.

Chick weight was not significantly related to diet after adjusting for mean tarsus length in a multiple regression ($F_{1,18} = 0.23$, $P = 0.634$) although the trend was positive (slope: 0.03 ± 0.06).

Nest survival during the nestling stage was not significantly related to the amount of weed seeds in the diet of the chicks ($\chi^2_1 = 1.11$, $P = 0.292$) and in this case the trend was negative (slope on logit scale: -0.81 ± 0.75).

4.6 Discussion

4.6.1 Habitat Use

The home-range sizes of Turtle Doves were highly variable, from 0.3 ha to 1130 ha, during this study. On average the home ranges of Turtle Doves at Deeping St Nicholas were over five times larger than those at Ixworth Thorpe. This difference is due mainly to the geographical distance between nesting and feeding sites, which at Deeping St Nicholas was much greater.

Information from radio-tracking suggested that Turtle Doves located their territories in a non-random way. The cropped habitats were particularly under-used and wooded ones most used relative to availability. The latter reflects the species' behaviour of loafing near the nest site or in tall trees and hedges where most territorial behaviour is conducted. The under-use of cropped areas, particularly cereals, is to be expected because Turtle Doves were recorded using this habitat only after harvest.

Throughout the study, Turtle Doves were highly dependent on food made available by human activities (spilt grain, livestock feed, maintained feeding sites and harvested stubbles) and appeared to make little use of "natural" sites. In 1999, circumstances produced two types of feeding sites that were exploited by Turtle Doves. At Ixworth Thorpe the principal feeding site was an area of oilseed rape, which having been heavily grazed by Rabbits and Woodpigeons in early spring, was heavily infested with weeds, primarily Field Pansy. At Deeping St Nicholas, the principal feeding site was fields of Daffodils, which after dying back in late spring became heavily infested with weeds, primarily Common Fumitory. These sites (one at Ixworth Thorpe and two at Deeping St Nicholas) were used for almost the entire breeding season by large numbers of Turtle Doves. The number of doves recorded at each feeding site represented at least 50% of the doves known to be present at each of the study sites, and as such shows the importance of these feeding areas. The foraging behaviour of Turtle Doves today is different to that recorded by Murton at his study site at Carlton in the 1960s. The difference in behaviour is largely attributable to the disappearance or different management (i.e. more efficient and intensive management) of the habitats that Turtle Doves used 40 years ago. This difference in habitats has occurred nationally (O'Connor & Shrubb 1986) and it is likely that the change in foraging behaviour observed by this study has occurred throughout the species' range in the UK.

4.6.2 Diet

Turtle dove diet was evaluated in this study from seed remains identified in faecal samples. Evaluation of this method, by comparison with crop contents from dead birds, and faecal material from captive birds with a known diet, showed that identification of seed fragments within faecal material accurately assessed diet. The assessment of dietary composition by estimating percentage cover of seed testa and seed surface did not produce different results.

In common with previous studies the seeds identified in the diet reflected those available at the sites where Turtle Doves were seen feeding. However, unlike other studies, Wheat and rape seeds were the main dietary component for Turtle Doves studied here, as opposed to the weed seeds that were recorded by others. The seeds from cultivated plants (Wheat and rape) constituted 69% on average of the seeds identified in the faecal samples of nestlings, and 60% of the seeds taken by adults. In Murton's study (Murton *et al.* 1964) the percentages were 23% and 5% respectively. It is likely that these differences are due to dietary change and not to the different methodologies used by each study to assess diet.

Recent changes in agricultural practices have removed and reduced many of the feeding opportunities available during Murton's time. Feeding sites favoured in the 1960s, such as hayfields, Clover leys and haystooks, have almost disappeared from the British countryside (O'Connor & Shrubb 1986). At the same time, increased use of herbicides and fertilisers and more efficient screening procedures have reduced weed abundance and diversity throughout the farmed environment. It is therefore likely that weed seed availability is greatly reduced today compared to 40 years ago (O'Connor & Shrubb 1986).

In terms of nutritional value, the apparent change in Turtle Dove diet away from weed seeds to cultivated seeds may not be detrimental to the species, but could in fact be beneficial. The energy value of rape and Wheat is approximately 24 kJ/g and 15kJ/g respectively (Diaz 1990), whereas the comparative values for a range of weed seeds is 1.8 to 12.1 kJ/g (Glück 1985). However, the results from this study suggest that differences in diet (i.e. more or fewer weed seeds) do not affect chick condition or fledging success. Equally important to consider is that the availability of cereal crop seeds, in the form utilised by Turtle Doves (i.e. spilt grain), has not increased over the last 40 years. It is likely that legislation introduced during the last decade pertaining to the secure storage of foodstuffs has in fact reduced availability. So it appears that given a choice between cultivated and non-cultivated seeds, Turtle Doves select weed seeds. However, the availability of rape has increased dramatically since Murton's time, having been introduced as a commercial crop only in the last 20 years. It is possible that when the rape seeds are available, Turtle

Doves are actually selecting to feed on them, as is the case with Linnets, which have switched their diet from weed seeds to rape seeds (Moorcroft *et al.* 1997, Moorcroft & Wilson 2000).

The greatest influence of dietary change is likely to be on the spatial and temporal availability of food during the course of the breeding season. The seeds from crops are generally most widely available immediately before, during and after harvest, which is at the end of the Turtle Doves' breeding season. Availability earlier is dependent on grain being spilt, which usually occurs during the movement of grain from storage. During periods when cereal prices are high, farm-based grain stores are emptied earlier than during periods when prices are low. In some years spilt grain may be available to Turtle Doves during the breeding season, in other years they may not. This is dependent solely on market pressures. Cultivated seed availability is not only limited and variable temporally, but also spatially. Whereas a weed-rich farming landscape would provide food for Turtle Doves throughout its home range, spilt grain is much more limited in its distribution and may occur in only one or two sites within a large geographical area, forcing birds to travel large distances between nesting and feeding habitats. This is particularly apparent at Deeping St Nicholas where the distances between feeding and nesting sites were greater than at Ixworth Thorpe and, consequently, where birds had larger home ranges and greater foraging distances, sometimes in excess of 10 km.

It is possible that reduced food availability and increased foraging distance, whilst not affecting breeding success per nesting attempt, may be affecting adult body condition and overall breeding performance by restricting the number of nesting attempts during the breeding season. Evidence from this study (Section 3.4.4) suggests that the Turtle Dove's breeding season has contracted and has shown that the number of nesting attempts per pair is greatly reduced, compared to 40 years ago. Reduced food availability early in the breeding season may result in birds being unable to attain suitable body condition until later. This may be particularly important for a migrant species, which must restore the loss of body condition resulting from migration before breeding can commence. Equally, reduced food availability and increased foraging distances after breeding has started may cause adults to lose condition and cease breeding much sooner.

CHAPTER 5

PLANT ABUNDANCE, SEED AVAILABILITY AND PESTICIDE USE

5.1 Introduction

The importance of food availability was discussed in Chapter 4. This Chapter aims to establish how food availability varies in relation to habitat, time during the breeding season and herbicide use.

Turtle doves feed exclusively on seeds and in the 1960s consumed predominately those from non-cultivated plants (weeds). Seeds from a wide range of plants were taken, with the composition of the diet apparently reflecting the seeds available within the feeding areas. To find out more about the availability of weed seeds to Turtle Doves in the modern agricultural environment, and how that availability varied in the course of the breeding season, regular plant surveys were carried out in 1998-2000 at Ixworth Thorpe and Deeping St Nicholas. In addition, information on herbicide use was collected at Ixworth Thorpe and to a lesser extent at Deeping St Nicholas, to help interpretation of the plant data.

5.2 Methods

5.2.1 Plant surveys

Information on weed species and their seed development during the course of the breeding season was collected at monthly intervals from May to August at approximately 50 random locations at Ixworth Thorpe and approximately 50 at Deeping St Nicholas. At Ixworth Thorpe all fields were surveyed using a 1-m^2 quadrat placed randomly within the crop and on the crop edge. At Deeping St Nicholas the 50 quadrats were assigned to the crops in approximately the same proportion as the crops occurred on the study site. Additionally about 5-10 plant surveys were undertaken on rough areas, including the two principal "natural" feeding sites that were particularly attractive to Turtle Doves in June and July, one on each of the intensive study areas (cf section 4.4.3).

The following variables were measured within each 1-m^2 quadrat: plant species present, ground cover of each species, which plants were seeding or in flower; and vegetation height. The proportion of potential seedheads at each of five stages (bud, flower, immature seedhead, ripe seedhead and spent seedhead) was also estimated for each plant species. The presence of fallen seed was also noted.

5.2.2 Pesticide information

Given the difficulty of collecting pesticide usage information from a number of sites with different owners, farmers and tenants, the majority of this information was collected from Ixworth Thorpe, with some additional information coming from Deeping St Nicholas. Information was supplied for all pesticides used and included product (or chemical) name and application rates and application dates.

5.2.3 Statistical analysis

Multi-way analysis of variance (ANOVA) was used to investigate the effect of year, site, month and habitat (and interactions) on the number of weed species (transformed to logarithms) in different habitat types. Only data from quadrats placed in the centre of the crops were used for this analysis. A similar analysis was used to compare the number of weed species growing in the centre and edge of the crop, using data from all quadrats.

For individual species, adequate data for analysis were obtained for Common Chickweed, Field Pansy, Common Fumitory, Knotgrass and Redshank. For each of these five species, multi-way analysis of variance (ANOVA) was used to test the effect of year, site, month and habitat (and interactions) on percentage weed cover and the percentage of plants with mature seed heads, after transforming the data to logits. To investigate seed availability in different habitats and through the breeding season, an index of ripe seedhead abundance was defined as % cover in quadrat x % ripe seedheads, and analysed in the same way.

To investigate the effect of herbicide applications on seed availability for the five main weed species, the percentage of plants with ripe seedheads (logit-transformed) and the index of ripe seedhead abundance were related to the number of herbicide applications, using analysis of covariance (ANCOVA) to adjust for potential site and year effects (but not for habitat, as this was a major source of variation in the number of herbicide applications). Plant data for May and herbicide data from sowing until the end of May were used, as May was considered to be the most important period during which food availability was likely to dictate Turtle Dove density. The unit for analysis was taken to be the quadrat.

5.3 Results

5.3.1 Weed abundance in different crops

Over 36 plant species were recorded in addition to the crop plants at Ixworth thorpe and Deeping St Nicholas (Table 5.1). Of these, grasses were the most common species. When considering the total number of weed species per quadrat, there was a significant interaction between site and habitat ($F_{5,91} = 4.81$, $P < 0.001$). Consequently, data from each intensive study site were analysed separately. When this was done, no further significant interactions were detected. At both sites the average number of weed species per quadrat differed significantly between habitat types (Ixworth Thorpe: $F_{5,142} = 77.1$, $P = 0.007$, Deeping St Nicholas: $F_{5,379} = 10.51$, $P < 0.001$) and between months of the breeding season (Ixworth Thorpe: $F_{3,142} = 3.76$, $P = 0.012$, Deeping St Nicholas: $F_{3,379} = 4.08$, $P = 0.001$). The lowest number of weed species was recorded within fields of winter cereals, where generally one species of weed was recorded in addition to the crop plant. The highest number of weed species was recorded on rough ground, where generally about six species of weeds were observed (Figure 5.1).

Table 5.1 The weed species recorded at the intensive study sites (1998-2000), the percentage of quadrats in which the species were recorded and the mean cover (%) of each species within 1-m^2 quadrats during 1998-2000. The s.e. of mean cover is given.

Weed species	Percentage of quadrats	Cover (%)	s.e.
Grasses	22.2	25.4	3.5
Common Field Speedwell	7.5	7.0	1.5
Common Nettle	7.2	15.6	5.0
Redshank	7.2	8.4	3.2
Creeping Thistle	6.3	6.8	1.3
Black Bindweed	6.3	5.0	0.9
Common Cleavers	6.3	4.1	0.9
Scentless Mayweed	4.8	15.6	4.2
Common Chickweed	4.8	8.1	2.0
Fat Hen	3.0	3.4	0.9
Groundsel	2.7	11.6	4.0
Broad-leaved Dock	2.1	20.7	8.8
Knotgrass	2.1	12.9	2.4
Field Pansy	1.8	4.2	1.3
Fig-leaved Goosefoot	1.5	12.0	2.5
Ribwort Plantain	1.5	7.0	1.2
Dandelion	1.5	6.6	2.1
Creeping Buttercup	1.2	28.0	9.9
Common Fumitory	1.2	6.5	2.2
White Clover	0.9	55.0	22.9
Common Poppy	0.9	9.0	3.8
Daisy	0.9	5.3	2.4
Ground Ivy	0.9	4.3	0.7
Hogweed	0.6	15.0	5.0
Dovesfoot Cranesbill	0.6	12.5	7.5
Rosebay Willowherb	0.6	7.5	2.5
Shepherd's Purse	0.6	4.5	1.5
Hedge Mustard	0.6	4.0	1.0
Common Mallow	0.3	35.0	10.0
Cow Parsley	0.3	32.5	5.0
Umbelliferae	0.3	11.0	0.5
Yarrow	0.3	7.5	0.0
Swine Cress	0.3	7.5	0.0
Common Ragwort	0.3	7.5	0.0
White Campion	0.3	6.5	0.5
Charlock	0.3	1.5	0.0

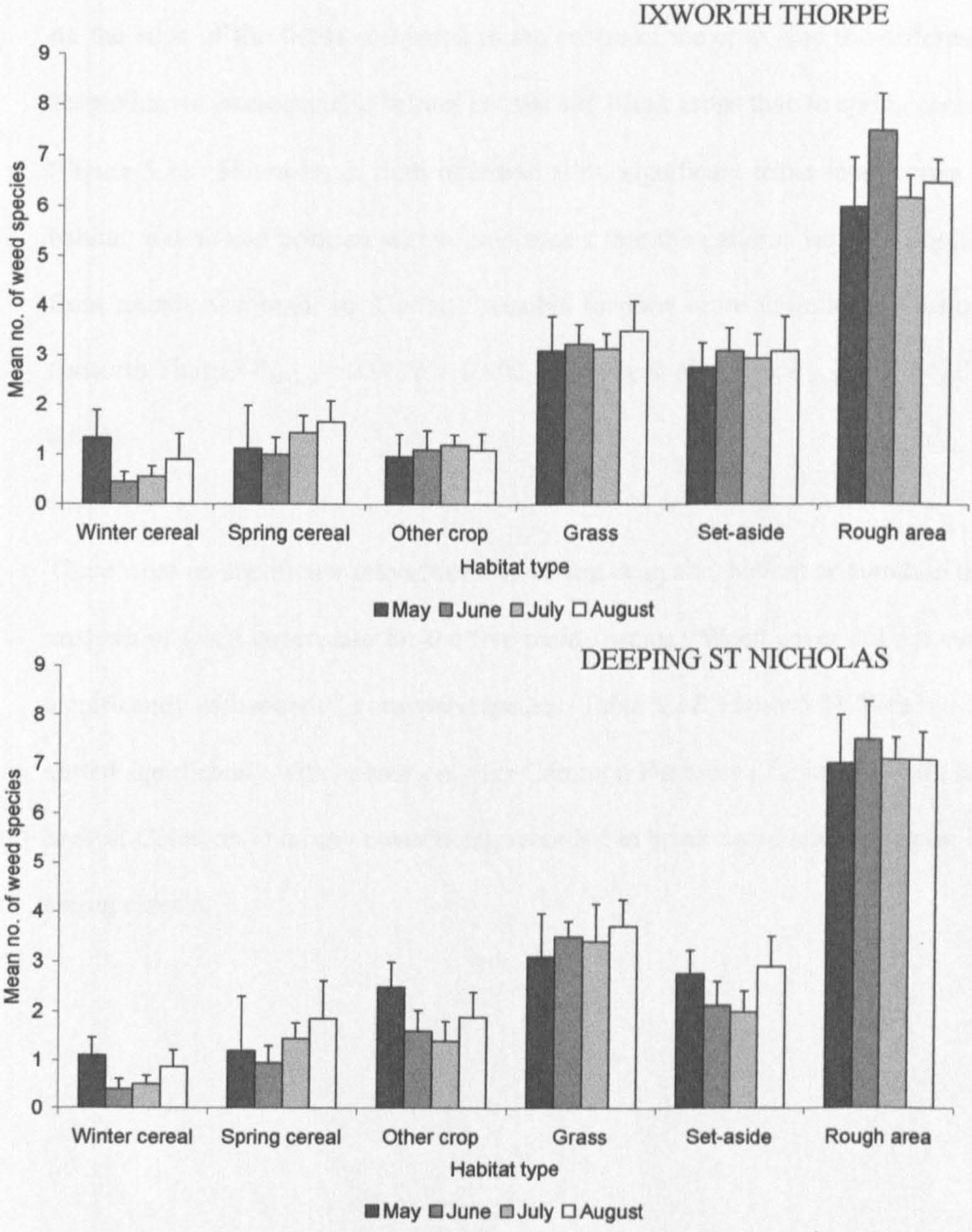
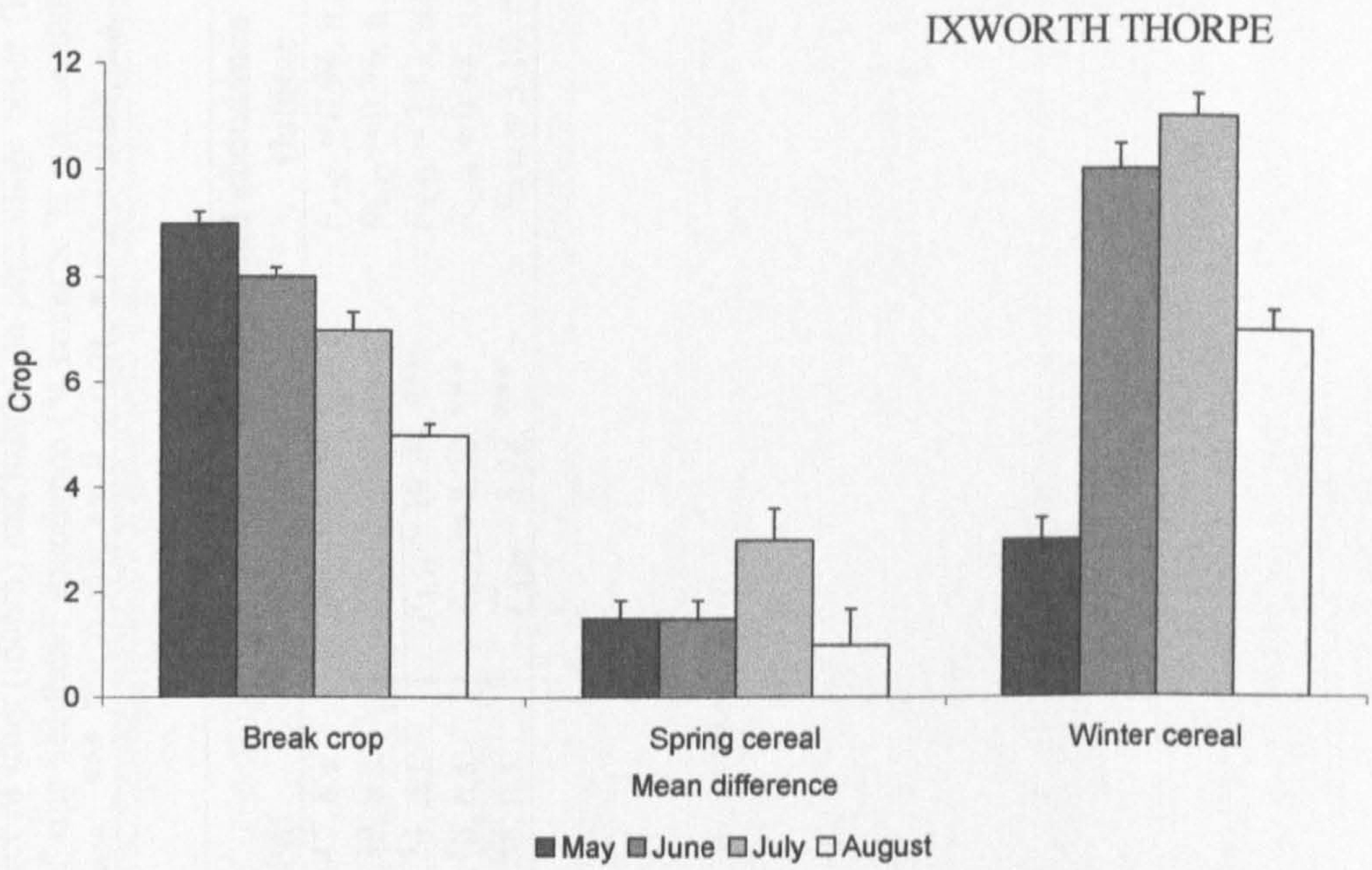


Figure 5.1 The mean number of weed species recorded per 1-m^2 quadrat in six different habitat types at Ixworth Thorpe and Deeping St Nicholas during May to August. The error bars represent 1 s.e.

Within the arable crops, the number of weed species recorded was apparently higher on the edge of the fields compared to the centre of the crop, and the difference seemed more pronounced in winter cereals and break crops than in spring cereals (Figure 5.2). However, at both intensive sites, significant triple interactions of habitat, month and position within crop meant that the patterns varied according from month to month, so it is not possible to draw more definite conclusions (Ixworth Thorpe: $F_{10,222} = 2.96$, $P = 0.002$, Deeping St Nicholas: $F_{10,462} = 2.64$, $P = 0.004$).

There were no significant interactions involving year, site, habitat or month in the analysis of weed cover data for the five main species. Weed cover did not vary significantly with month for any weed species (Table 5.2 & Figure 5.3). Weed cover varied significantly with habitat only for Common Fumitory (Table 5.2), with the highest Common Fumitory cover being recorded in break crops and the lowest in spring cereals.



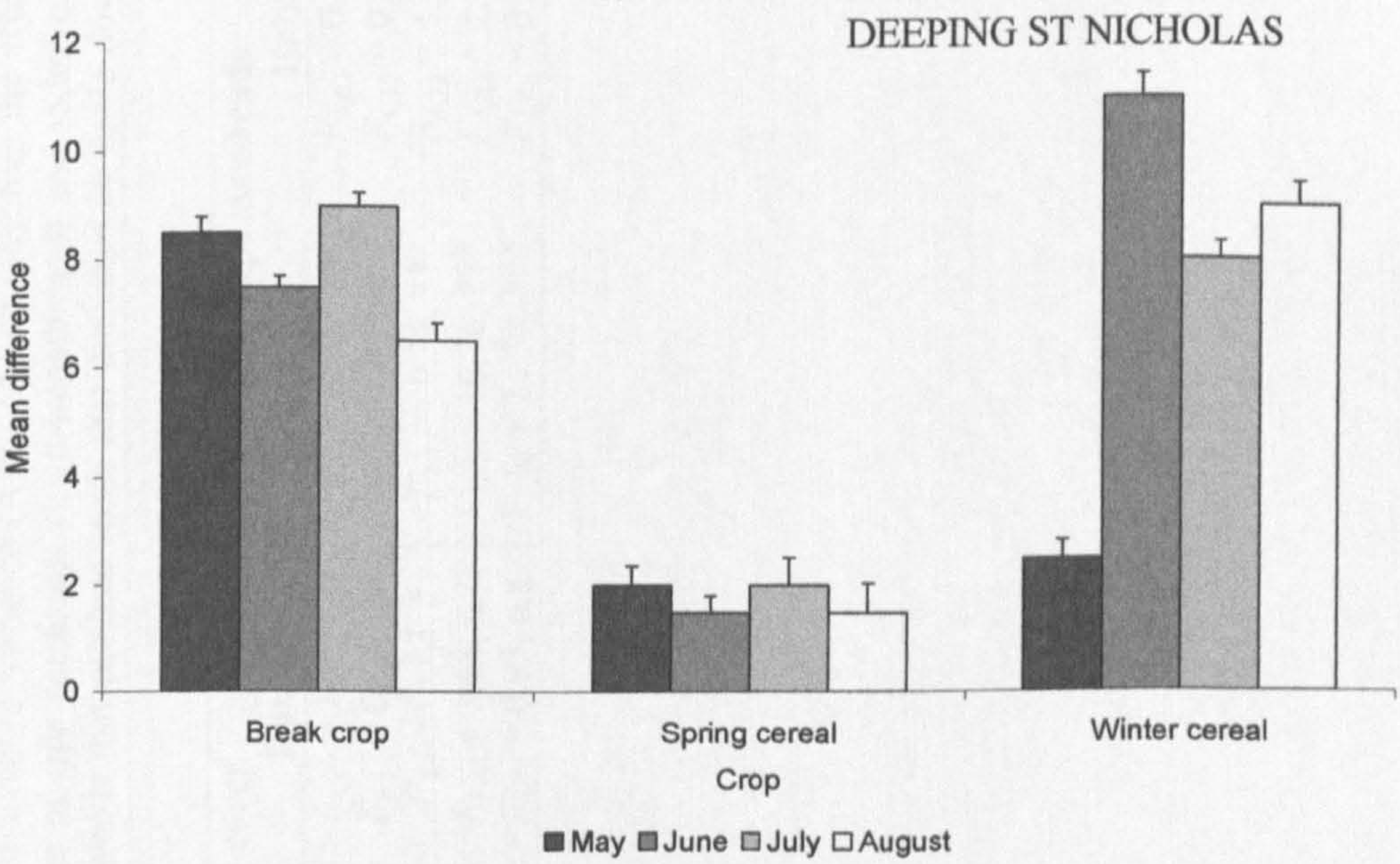


Figure 5.2 Mean difference in number of weed species recorded per 1-m^2 quadrat between the edge and centre of arable crops at Ixworth Thorpe and Deeping St Nicholas during May to August. The error bars represent 1 s.e.

Table 5.2 F-values arising from Analysis of Variance (ANOVA) investigating the effect of time (month) and habitat on percentage cover (logit-transformed), percentage of ripe seedheads (logit-transformed) and index of ripe seedhead abundance (% cover x % ripe seedheads) recorded for the main weeds that produce seeds that are eaten by turtle doves. *** $P < 0.001$, ** $P < 0.01$, * = $P < 0.05$, n.s. non-significant.

	Weed cover		Ripe seedheads		Index of ripe seedhead abundance	
	Month	Habitat	Month	Habitat	Month	Habitat
Chickweed	$F_{3,67} = 0.42$, n.s.	$F_{4,67} = 1.22$, n.s.	$F_{3,67} = 8.70$, ***	$F_{4,67} = 0.45$, n.s.	$F_{3,67} = 2.56$, n.s.	$F_{4,67} = 0.94$, n.s.
Field pansy	$F_{3,13} = 1.32$, n.s.	$F_{4,13} = 0.61$, n.s.	$F_{3,13} = 4.77$, *	$F_{4,13} = 0.39$, n.s.	$F_{3,13} = 1.54$, n.s.	$F_{4,13} = 0.26$, n.s.
Fumitory	$F_{3,11} = 0.81$, n.s.	$F_{4,11} = 3.83$, *	$F_{3,11} = 9.35$, **	$F_{4,11} = 1.24$, n.s.	$F_{3,11} = 19.70$, ***	$F_{4,11} = 2.53$, n.s.
Knotgrass	$F_{3,43} = 0.18$, n.s.	$F_{4,43} = 3.68$, n.s.	$F_{3,43} = 10.76$, ***	$F_{4,43} = 1.18$, n.s.	$F_{3,43} = 8.78$, ***	$F_{4,43} = 0.38$, n.s.
Redshank	$F_{3,76} = 2.33$, n.s.	$F_{4,76} = 0.93$, n.s.	$F_{3,76} = 24.39$, ***	$F_{4,76} = 0.84$, n.s.	$F_{3,76} = 5.98$, ***	$F_{4,76} = 3.10$, *

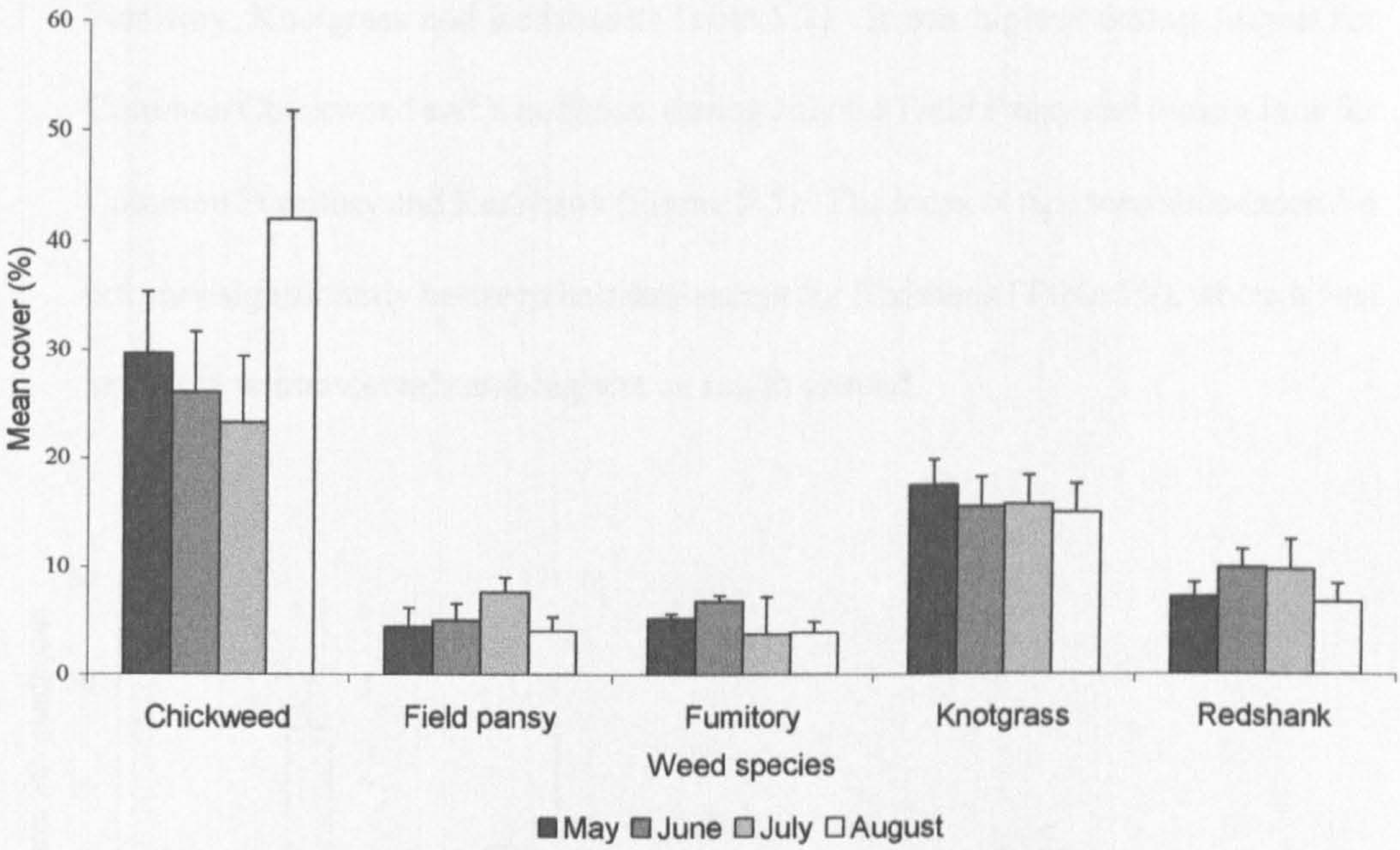


Figure 5.3 Mean weed cover (%) for the main species of weeds that were components of turtle dove diet (see text), recorded per 1-m^2 quadrat during May to August at the intensive sites (1998-2000). The error bars represent 1 s.e.

5.3.2 Seed availability

There were no significant interactions involving year, site, habitat or month in the analysis of ripe seedhead proportion and abundance index data. The proportion of seedheads that contained ripe seeds varied significantly with month for all of the main weed species; Common Chickweed, Field Pansy, and Knotgrass had the highest proportion of ripe seedheads in August, with Redshank and Common Fumitory having the highest proportion in June (Table 5.2 & Figure 5.4). The proportion of seedheads that were ripe did not vary significantly with habitat for any species (Table

5.2). The index of ripe seed abundance varied significantly with month for Common Fumitory, Knotgrass and Redshank (Table 5.2). It was highest during August for Common Chickweed and Knotgrass, during July for Field Pansy and during June for Common Fumitory and Redshank (Figure 5.5). The index of ripe seed abundance did not vary significantly between habitats except for Redshank (Table 5.2), where it was lowest in winter cereals and highest on rough ground.

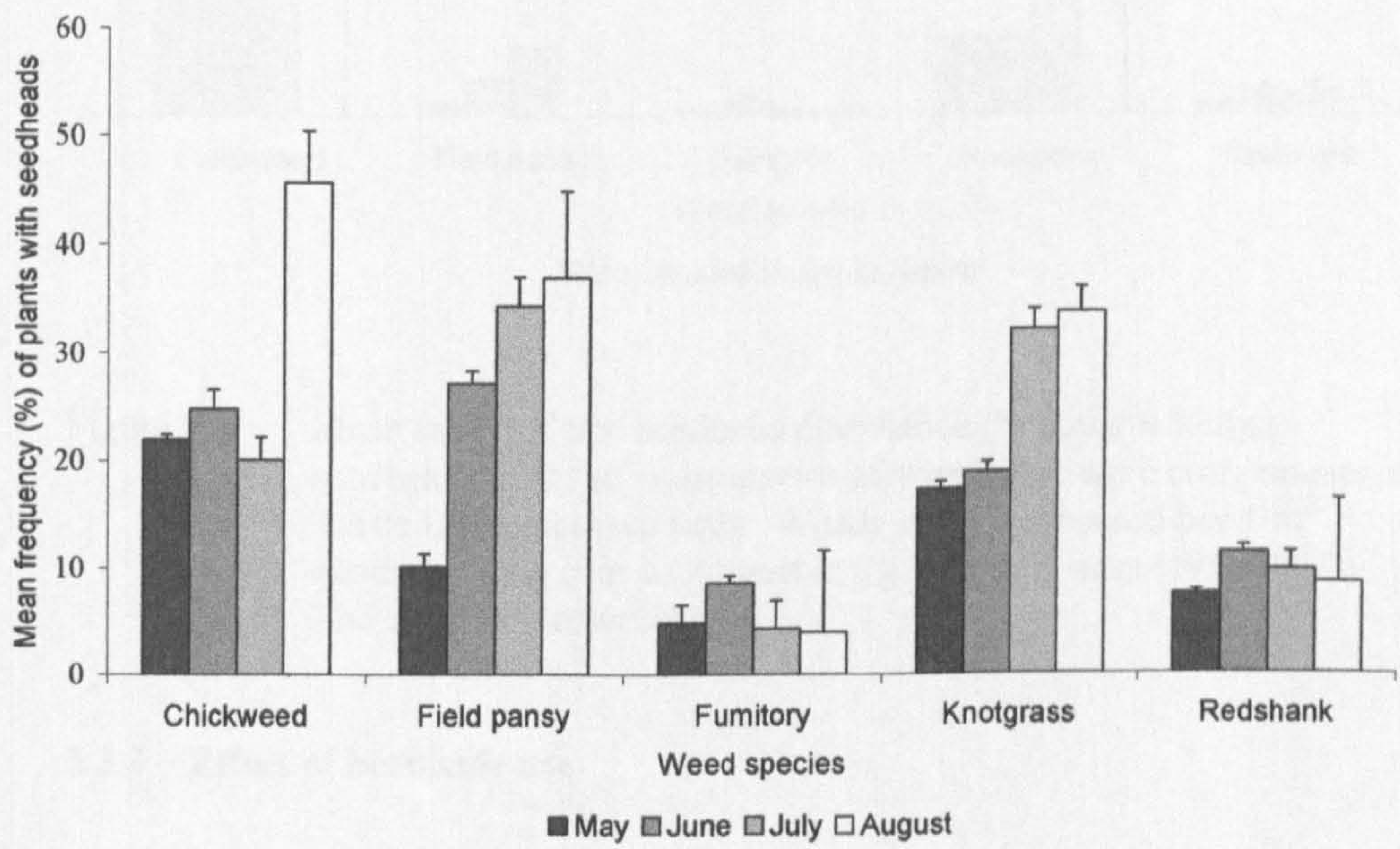


Figure 5.4 Mean frequency (%) of plants with ripe seedheads for the main species of weeds that were components of Turtle Dove diet (see text). Weed species recorded per 1-m^2 quadrat during May to August at the intensive (1998-2000) and experimental sites (1999-2000). The error bars represent 1 s.e.

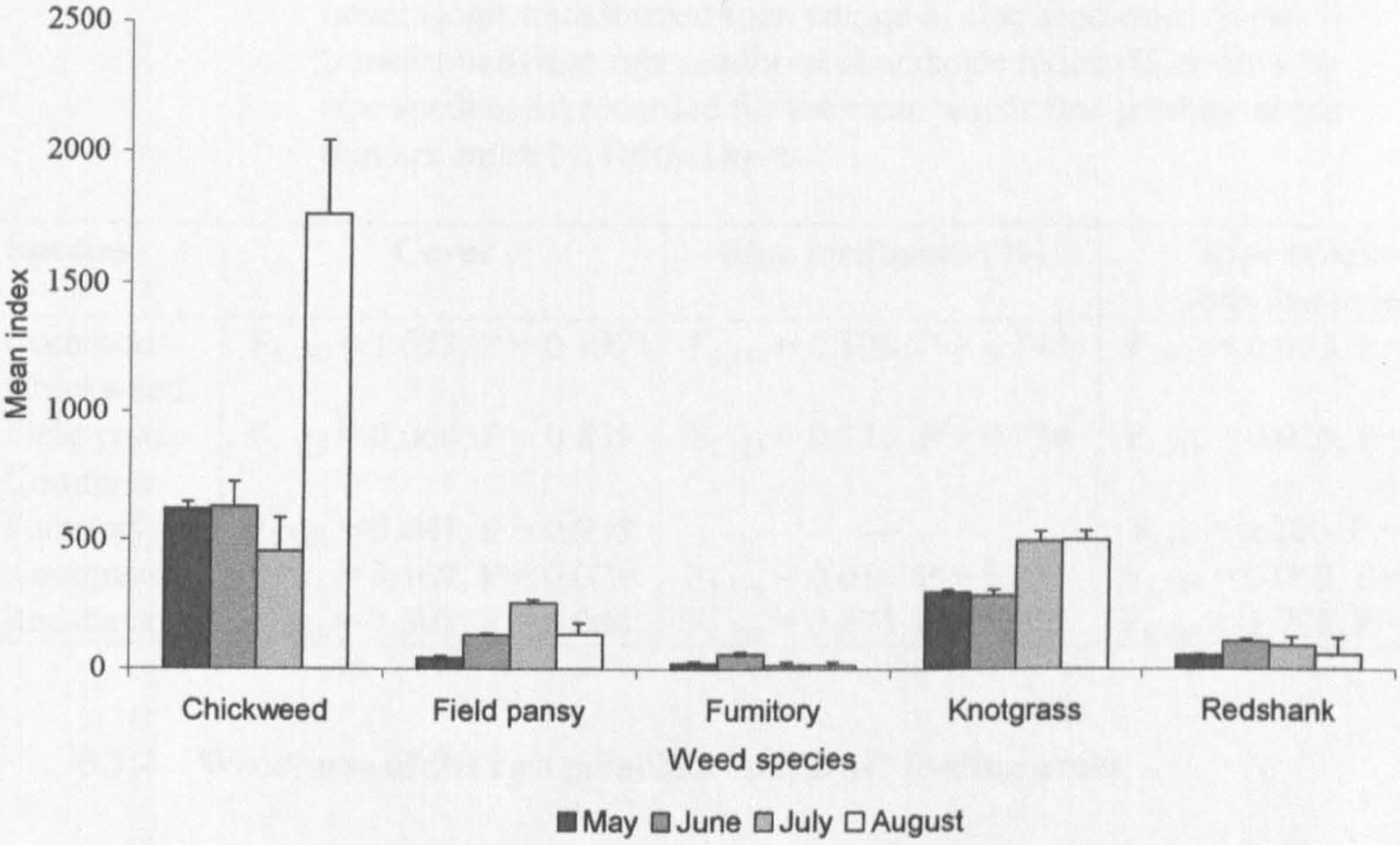


Figure 5.5 Mean index of ripe seedhead abundance (% cover x % ripe seedheads) for the main species of weeds that were components of Turtle Dove diet (see text). Weeds species recorded per 1-m^2 quadrat during May to August at the intensive sites (1998-2000). The error bars represent 1 s.e.

5.3.3 Effect of herbicide use

There were no significant interactions involving year and site in the analysis of May weed cover, May proportion of ripe seedheads and May seedhead abundance index in relation to herbicide use. None of these three variables was significantly linked to the number of herbicide applications for any of the five main weed species (Table 5.3).

Table 5.3 *F*-values arising from Analysis of Covariance (ANCOVA) investigating the effect of herbicide applications on percentage cover (logit-transformed) percentage of ripe seedheads (logit-transformed) and ripe seedhead abundance index (% cover x % ripe seedheads) recorded for the main weeds that produce seeds that are eaten by Turtle Doves

Species	**Cover**	**Ripe seedheads (%)**	**Ripe seedhead abundance index**
Common Chickweed	$F_{1,130} = 1.682, P = 0.197$	$F_{1,130} = 0.108, P = 0.743$	$F_{1,130} = 0.062, P = 0.804$
Field pansy	$F_{1,113} = 0.064, P = 0.839$	$F_{1,113} = 0.116, P = 0.734$	$F_{1,113} = 0.026, P = 0.871$
Common Fumitory	$F_{1,113} = 0.041, P = 0.938$	—	$F_{1,00} = 0.280, P = 0.598$
Knotgrass	$F_{1,114} = 3.167, P = 0.078$	$F_{1,114} = 0.010, P = 0.921$	$F_{1,114} = 0.060, P = 0.807$
Redshank	$F_{1,124} = 7.895, P = 0.006$	$F_{1,124} = 0.975, P = 0.325$	$F_{1,124} = 1.728, P = 0.191$

5.3.4 *Weediness of the two principal "natural" feeding areas*

These areas (see chapters 4.4.3 and 4.6.1) were Rabbit/Woodpigeon-damaged Oil-seed Rape at Ixworth Thorpe in 1999 and Daffodil fields at Deeping St Nicholas in 1999-2000. They were used by Turtle Doves especially in June and July, and received no spring or summer herbicide applications. The mean number of weed species per quadrat on these areas was around twice that in quadrats elsewhere on the intensive study sites in June-July 1998-2000 (Table 5.4). Considering the five main weed species, average proportions of ripe seedheads were very similar on the feeding areas and the study sites for all species, but weed cover was higher on the feeding areas for six out of seven comparisons (Table 5.4). In particular, it was ten times higher for Field Pansy at Ixworth Thorpe and six times higher for Common Fumitory at Deeping St Nicholas. These differences carried through to the index of ripe seedhead abundance.

Table 5.4 The number of weed species recorded during June-July on the two intensive study sites in 1998-2000 and on the two principal 'natural' feeding sites used by Turtle Doves in 1999-2000, together with mean weed cover, percentage of plants with ripe seedheads and index of ripe seedhead abundance for the five main weed species. Means are given ± 1 s.e.

Habitat Type	No of quadrats	No of weed species	Main species recorded	Cover (%)	Ripe seedheads (%)	Ripe seedhead abundance index
Ixworth Thorpe Study site	300	1.9 ± 0.5	Chickweed	11.3 ± 0.3	24.2 ± 2.6	272.8 ± 21.9
			Field pansy	4.1 ± 0.7	29.3 ± 3.3	121.3 ± 19.5
			Common Fumitory	7.8 ± 0.4	10.3 ± 2.2	81.3 ± 13.6
			Knotgrass	13.4 ± 0.6	26.4 ± 2.1	354.5 ± 64.3
			Redshank	10.3 ± 0.2	11.4 ± 2.4	118.3 ± 13.1.0
Damaged oil-seed rape	6	4.3 ± 0.3	Chickweed	17.9 ± 0.6	30.8 ± 3.1	552.1 ± 111.1
			Field pansy	38.9 ± 0.5	25.2 ± 1.1	978.3 ± 96.3
			Redshank	12.6 ± 0.2	10.0 ± 1.7	127.2 ± 17.6
Deeping St Nicholas Study site	307	2.5 ± 0.1	Chickweed	10.2 ± 0.4	29.6 ± 1.6	302.9 ± 76.4
			Field pansy	3.2 ± 0.2	21.3 ± 2.1	68.2 ± 26.8
			Common Fumitory	8.1 ± 0.3	6.5 ± 1.9	53.7 ± 17.4
			Knotgrass	14.2 ± 0.5	13.5 ± 1.8	192.4 ± 46.2
			Redshank	11.1 ± 0.6	13.4 ± 1.1	149.6 ± 17.5
Daffodil fields	8	4.0 ± 0.5	Chickweed	15.3 ± 0.2	31.8 ± 0.7	486.3 ± 98.6
			Field pansy	7.6 ± 0.4	21.2 ± 2.6	161.2 ± 35.8
			Common Fumitory	36.7 ± 0.3	11.8 ± 1.9	433.2 ± 198.6
			Knotgrass	8.9 ± 0.1	12.5 ± 1.7	112.1 ± 37.3

5.4 Discussion

A higher number of weed species were recorded in the non-crop habitats compared to the crop habitats. In addition, within the crops the number of weed species was higher on the field edge compared to the crop centre. Although not apparent from this study it is generally accepted that this difference is due partly to the application of herbicides, which have been designed and applied deliberately to reduce weed abundance and seed availability (Wilson 1992). Evidence from the plant surveys suggests that the majority of arable habitats are less suitable for feeding Turtle Doves compared to the unmanaged areas, such as set-aside and rough ground. The key feeding areas for Turtle Doves at the intensive study sites were on the more weedy areas, which received no herbicide applications during the breeding season, and were particularly rich in Field Pansy, Common Fumitory and Common Chickweed. The implication of this is that large areas of the intensively farmed arable landscape are not suitable for feeding Turtle Doves.

The findings of this study suggest that food availability during the breeding season may be one of the factors driving the population decline in the UK. It is therefore necessary to reverse the decline in weed-rich areas suitable for use by Turtle Doves. Given that herbicide use is an essential part of modern agriculture, arable fields will continue to be unsuitable feeding areas for Turtle Doves. It is therefore important to establish weed-rich habitats within the modern farming system, either within or adjacent to arable fields. These weed-rich habitats need to be widespread across the

Turtle Dove's range.

The ideal habitat appears to be one that receives annual tillage and no herbicide, which allows the development of a short and sparse covering of annual weeds. This is similar to Uncropped Wildlife Strips within the Breckland Environmentally Sensitive Area and could be provided also by appropriate field-margin management within the Countryside Stewardship scheme and the recently introduced Arable Stewardship scheme. Although set-aside generally produces vegetation that is too tall and dense for Turtle Doves, sparsely sown set-aside using the Wild Bird Cover option may benefit the species, especially if Common Fumitory seeds are included within the mixture.

CHAPTER 6

EXPERIMENTAL MANIPULATION OF FOOD RESOURCES

6.1 Introduction

The importance of food availability in relation to breeding success has been discussed in Chapter 4. The results from Chapter 4 show that Turtle Doves make little use of natural feeding sites and use sites where the food arose from man's activities. Additionally, Turtle Doves were travelling large distances to use these sites and were congregating in comparatively large numbers, demonstrating the importance of these sites to local breeders. This change in feeding behaviour led to a shift in Turtle Dove diet which now comprises less than half the proportion of weed seeds than in the early 1960s. Since the 1960s, increased use of herbicide has greatly reduced the number of arable weeds (O'Connor & Shrubb 1986), to the extent that some once common plants (e.g. Cornflower & Corn Cockle) are now rare (Wilson 1992). It is therefore possible that reduced food availability is affecting the ecology and breeding success of Turtle Doves.

A number of studies have shown that supplementary feeding can alter the breeding performance of a range of bird species. Supplementary feeding can induce earlier and/or longer breeding seasons, may increase clutch size and increase chick survival in raptors (e.g. Sparrowhawk (Newton and Marquiss 1981), Kestrel (Dijkstra *et al.* 1982)), corvids (e.g. Carrion Crow (Yom-Tov 1974), Magpie (Dhindsa & Boag 1990)) and passerines (e.g. Great Tit (Kallander 1974), Willow & Crested Tit (Brömssen & Jansson 1980), Anna Hummingbird (Ewald & Rohwer 1982)). Supplementary feeding can also induce more nesting attempts and quicker re-nesting (e.g. Song Sparrow (Arcese & Smith 1988), Pheasant (Hoodless, *et al.* 1999)). Accordingly, an experiment was conducted in 1999 and 2000 to investigate whether providing supplementary food had significant effects on territory density, territory size and breeding success of the Turtle Dove.

6.2 Methods

Ten study sites across Norfolk and Suffolk (as detailed in Chapter 2.1.3) were used for the experiment. In 1999 five of the study sites chosen at random (Elveden, Hilborough, Little Dunham, Raveningham and Shadwell) received supplementary food (Wheat) from late April to late June. The other five study sites received no extra food. In 2000, the treatment was switched. Information from the pilot study and the first year of this study showed that Turtle Doves appeared to prefer to feed on areas with short and sparse vegetation and readily took spilt grain. On each study site receiving supplementary food, two to four equally spaced open areas with short sparse vegetation were selected as feeding areas. These were usually tracks, farm yards and concrete hard standings. The number of feeding areas was dependent on the size of the study site. At each feeding area approximately 2-3 kg of wheat were poured onto the ground, over an area of about 2 m^2. Food supplies were checked every few days to ensure a constant supply throughout the feeding period. The food supplies were also watched at regular intervals to ensure that Turtle Doves were eating the food.

Territory mapping was used to collect information on Turtle Dove territory density using the same methods described in Chapter 3. Breeding success was measured through nest finding and monitoring, and habitat use was assessed through the observation of feeding birds (see Chapter 4). Fieldwork was carried out between late April and late August at all ten sites in 1999 and 2000.

6.3 Statistical analysis

Three-way analysis of variance (ANOVA) was used to investigate the effect of year, site and treatment (fed or unfed) on territory density and territory size.

Analysis of daily nest survival probabilities was carried out using an extension of the Mayfield method that uses logistic regression to test for the effect of continuous variables and factors (Aebischer 1999). Here, year and site factors (and the interaction) were entered into the analysis to test for year and site effects.

6.4 Results

6.4.1 Territory density

Six of the ten study sites supported Turtle Dove territories in 1999, three on fed and three on unfed sites (Table 6.1). In 2000 Turtle Doves were recorded on seven of the study sites; four of these were fed and three were unfed. (Table 6.1). Territory density ranged from 0.24 to 3.25 territories per km^2 (Table 6.1). The average density on the fed sites was 1.43 ± 0.43 territories per km^2 and 1.60 ± 0.46 on the unfed sites, but this difference was not significant (ANOVA $F_{1,8} = 1.00$, $P = 0.347$).

Table 6.1 Densities (no. per km^2) and size (ha) of Turtle Dove territories on the ten experimental sites in relation to whether or not supplementary food was provided

Study site	Area (ha)	Year fed	Year unfed	Density		Territory size	
				Fed	Unfed	Fed	Unfed
Elveden	361	1999	2000	0.00	0.00	0.0	0.0
Gayton	209	2000	1999	0.00	0.00	0.0	0.0
Hardingham	257	2000	1999	0.39	0.00	3.87	0.0
Hilborough	259	1999	2000	1.93	1.93	2.66	3.01
Letheringsett	295	1999	2000	0.38	0.38	3.21	2.88
Little Dunham	98	1999	2000	2.04	2.04	1.96	1.64
Panworth	229	2000	1999	1.75	1.75	2.56	2.95
Raveningham	185	2000	1999	3.25	3.25	2.41	2.66
Sennowe	411	2000	1999	0.24	0.24	3.12	4.58
Shadwell	408	1999	2000	0.00	0.00	0.0	0.0
Mean				1.43	1.37	2.61	2.74
s.e.				0.43	0.45	0.17	0.31

6.4.2 Territory size

Territory size ranged from 1.96 to 3.87 ha on the fed sites and from 1.64 to 4.58 ha on the unfed sites (Table 6.1). The mean territory size was 2.61 ± 0.17 ha on the fed sites and 2.74 ± 0.31 ha on the unfed sites, but this difference was not significant (ANOVA $F_{1,31} = 0.171$, $P = 0.682$)

6.4.3 Timing of breeding

The nests found on the experimental sites were all initiated in June and July (Figure 6.1). Although there was a tendency for clutches to be initiated earlier and continue for longer at the fed sites compared to the unfed sites this difference was not significant ($\chi^2_3 = 4.072$, $P = 0.253$; Figure 6.1).

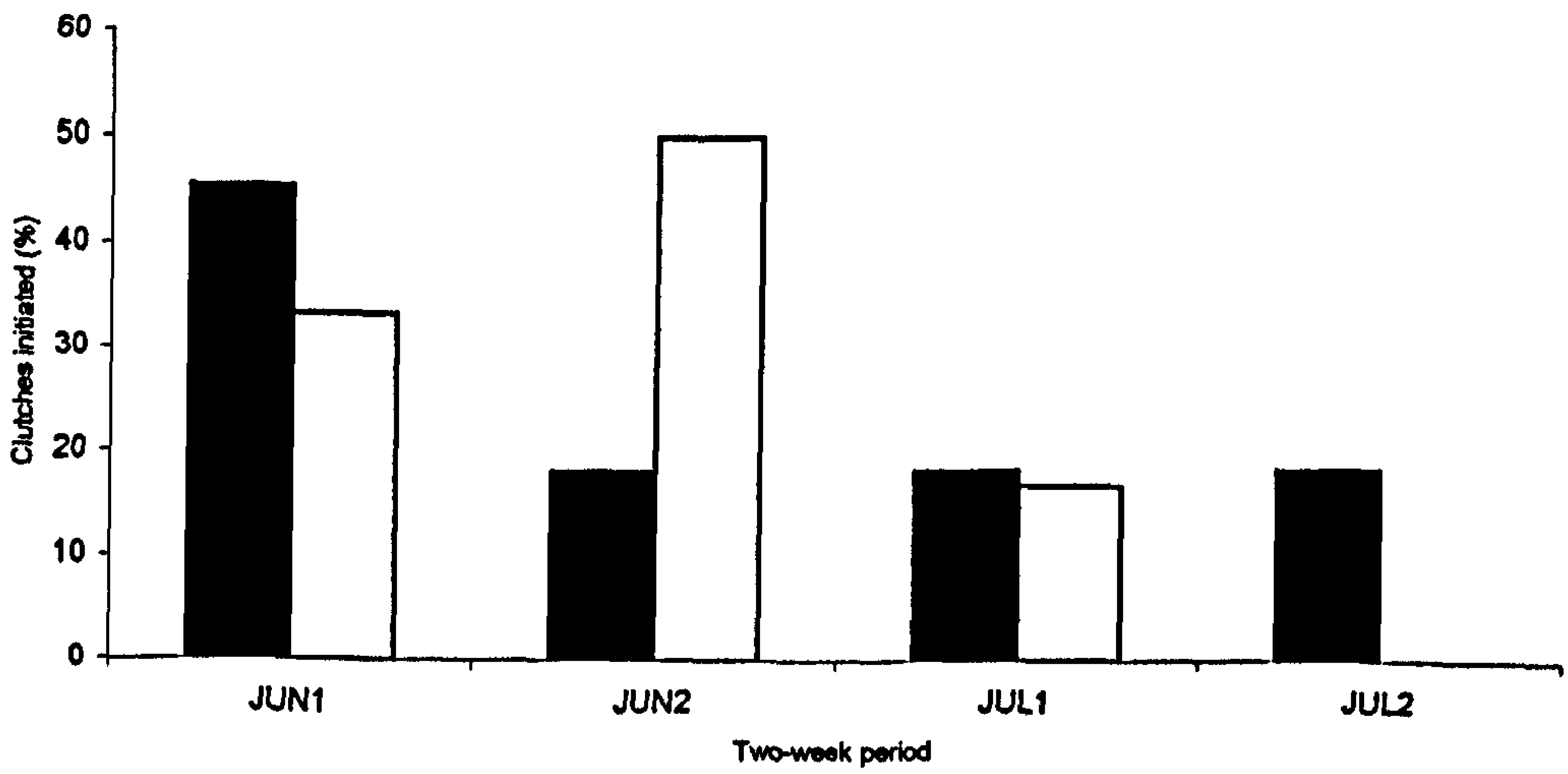


Figure 6.1 The frequency of clutches initiated during each two-week period of the breeding season at the fed (black bars) and unfed (white bars) experimental sites, combining data from 1999 and 2000.

6.4.4 Breeding success

Twenty-four nests were found on four of the study sites (Hilborough, Little Dunham, Panworth and Raveningham), 13 in 1999 and 11 in 2000. Descriptions of the nest sites are given in Table 6.2. All nests were found within hedgerows, scrub and young plantations. Hawthorn was the preferred tree species for nesting, with 50% of nests being found within it. Other nests were found in elder, Norway spruce and bramble. All nests were between 1.3 m and 4.0 m (median = 2.0 m) above ground level. Over half the nests (53%) were within 0.1 m of climbers and in most cases climbers were an integral part of the nest.

A summary of nest outcomes is given in Table 6.3. Of the 24 nests found, 12 successfully fledged 24 young. Six of the remaining twelve nests were abandoned. The other nests were predated.

Table 6.2 Nest-site descriptions for all Turtle Dove nests found on the 10 experimental sites,1999-2000

Nest no.	Study site	Year	Tree species	Height of bush (m)	Climber present	Nest height (m)	Distance (m) from Trunk	Edge	Climbers
1	Hilborough	1999	Hawthorn	4.5	Y	2.3	1.7	1.5	0.08
2	Hilborough	1999	Hawthorn	3.5	Y	2.6	1.4	1.0	1.0
3	Hilborough	1999	Hawthorn	3.2	N	2.1	0.5	0.7	N/A
4	Hilborough	1999	Elder	5.3	N	2.4	0.5	1.5	N/A
5	Panworth Hall	1999	Norway Spruce	7.0	Y	4.0	1.0	1.5	0.02
6	Panworth Hall	1999	Norway Spruce	5.0	Y	3.7	0.6	1.6	<0.1
7	Raveningham	1999	Holly	4.0	Y	2.5	0.5	1.7	0.1
8	Raveningham	1999	Hawthorn	4.5	Y	2.7	1.2	1.5	0.1
9	Raveningham	1999	Elder	2.5	Y	1.7	0.6	2.0	0.1
10	Raveningham	1999	Elder	4.5	Y	3.0	2.5	2.0	0.1
11	Raveningham	1999	Hawthorn	3.5	Y	1.3	1.2	2.5	<0.1
12	Raveningham	1999	Hawthorn	4.5	N	1.7	1.5	0.7	N/A
13	Little Dunham	1999	Hawthorn	4.0	N	2.5	1.5	1.0	N/A
1	Hilborough	2000	Hawthorn	6.0	N	2.5	2.0	0.5	
2	Hilborough	2000	Hawthorn			1.7			
3	Hilborough	2000	Hawthorn	5.5	Y	1.7	3.0	0.3	0.5
4	Little Dunham	2000	Norway Spruce	8.0	Y	1.9	0.6	0.1	0.0
5	Panworth Hall	2000	Bramble	3.0	Y	1.5		0.5	0.0
6	Panworth Hall	2000	Hawthorn	5.0	Y	1.7	1.0	0.2	0.1
7	Panworth Hall	2000	Bramble			2.0			
8	Raveningham	2000	Hazel	4.0	N	1.9	0.2	0.5	0.0
9	Raveningham	2000	Bramble			2.0			
10	Raveningham	2000	Hawthorn			2.0			
11	Raveningham	2000	Bramble			2.1			

Table 6.3 Summary of Turtle Dove nest outcome at the ten experimental study sites, 1999-2000

Nest no.	Study site	Date found	No. of eggs	No. of young	No. young fledged	Outcome
1	Hilborough	29/06/99	2	2	2	Fledged
2	Hilborough	29/06/99	2	2	0	Predated
3	Hilborough	29/06/99	2	2	2	Fledged
4	Hilborough	29/06/99	2	2	2	Fledged
5	Panworth Hall	30/06/99	2	2	2	Fledged
6	Panworth Hall	30/06/99	2	2	2	Fledged
7	Raveningham	02/07/99	2	0	0	Predated
8	Raveningham	15/06/99	2	2	2	Fledged
9	Raveningham	02/07/99	?	0	0	Predated
10	Raveningham	02/07/99	2	2	2	Fledged
11	Raveningham	02/07/99	0	0	0	Abandoned
12	Raveningham	02/07/99	0	0	0	Abandoned
13	Little Dunham	01/07/99	2	2	2	Fledged
1	Hilborough	12/06/00	2	0	0	Abandoned
2	Hilborough	19/07/00	2	2	2	Fledged
3	Hilborough	19/07/00	2	0	0	Abandoned
4	Little Dunham	21/07/00	2	2	0	Predated
5	Panworth Hall	21/07/00	2	0	0	Predated
6	Panworth Hall	21/07/00	2	0	0	Predated
7	Panworth Hall	21/07/00	2	2	2	Fledged
8	Raveningham	20/07/00	2	1	0	Failed
9	Raveningham	20/07/00	2	2	2	Fledged
10	Raveningham	20/07/00	2	1	0	Failed
11	Raveningham	20/07/00	2	2	2	Fledged

The daily survival rates for the fed sites during incubation and brood-rearing were 0.792 ± 0.037 and 0.971 ± 0.029 respectively, after adjusting for year and site. The daily survival rates for the unfed sites during incubation and brood-rearing were 0.850 ± 0.376 and 0.981 ± 0.019 respectively, after adjusting for year and site. Supplementary feeding did not affect the success of nests either during incubation ($\chi^2_1 = 0.772$, $P = 0.772$) or during the brood-rearing stage ($\chi^2_1 = 0.001$, $P < 0.975$).

Given the lack of treatment effect on nesting success, data from all experimental sites were pooled. The overall nesting success during incubation was 35.1 ± 13.8% and that during brood-rearing was 69.9 ± 17.7%. These values did not differ significantly from those observed at the intensive study sites, which were 53.1 ± 5.7% and 64.7 ± 6.5% respectively (incubation: $\chi^2_1 = 1.36, P = 0.254$, brood-rearing: $\chi^2_1 = 0.11, P = 0.752$).

The importance of nesting attempts per pair per annual has been shown in Chapter 3 to be the major change in Turtle Dove breeding ecology. It was not possible to assess the number of nesting attempts undertaken per pair on the experimental sites as it was highly unlikely that all nests of all pairs were found. However, on the fed sites the number of nesting attempts found per territory was 0.65, whereas on the unfed sites the corresponding value was 0.57. Although this difference is not significant it is in the predicted direction.

6.4.5 Feeding sites

Away from the supplementary food, Turtle Doves were seen feeding very infrequently and only at Hardingham, Hilborough, Panworth and Letheringsett. At all of the feeding locations, there was very little vegetation cover. The food consisted mostly of spilt grain or animal feed near farm buildings.

Turtle doves were seen using the supplementary food at Gayton, Hardingham, Panworth, Raveningham and Sennowe. They were usually in association with other dove and pigeon species. At the sites where Turtle Doves were not actually seen using the supplementary food, the food provided was always consumed within a few days and feathers and droppings were present, suggesting that a number of birds of a variety of species ate the supplementary food.

6.4.6 Diet

Faecal material was collected from 10 nests. The seeds identified in these samples are summarised in Table 6.4. In all cases the diet of the nestlings was comprised almost entirely of the seeds from cultivated plants (Wheat and rape) with less than 10% of the seeds being those of non-cultivated plants (weeds).

Table 6.4 The percentage composition of seeds identified in Turtle Dove faecal samples collected at the experimental sites during 1999-2000

Study Site	Year	Cultivated seeds	Non-cultivated seeds
Hilborough	1999	99.0	1.0
Hilborough	1999	97.0	3.0
Hilborough	1999	98.0	2.0
Panworth	1999	97.0	3.0
Raveningham	1999	100.0	0.0
Hilborough	2000	90.0	10.0
Panworth	2000	80.0	20.0
Raveningham	2000	85.0	15.0
Raveningham	2000	75.0	25.0
Raveningham	2000	90.0	10.0
Mean		91.1	8.9
s.e.		2.7	2.7

6.5 Discussion

The results from this experiment do not demonstrate that supplementary feeding increases Turtle Dove density or improves nesting success, although there is some evidence that supplementary food may induce earlier nesting and prolong the nesting season and may increase the number of nesting attempts undertaken per pair per annum. In retrospect, however, the experimental approach may have been inadequate in terms of scale. The low densities of Turtle Doves and the requirement to select study sites that could each be surveyed easily in one morning resulted in study sites that, although mostly exceeding 2 km^2 in area, contained only small numbers of territories and nests.

The aim of the experiment was to alter food availability to Turtle Doves. However, results obtained from the intensive part of this study demonstrated that Turtle Doves were able to range over a comparatively large area. This means that to alter Turtle Dove food availability it would be necessary to manipulate (remove or add) food over a very large area, which should probably exceed 1000 ha. To conduct an experiment of the type undertaken here, at this scale, would be extremely difficult. An additional problem was the amount of waste grain and tailings which were more available in the region than expected when the experiment was designed.

CHAPTER 7

RE-SURVEYING OF CARLTON

7.1 Introduction

The Ministry of Agriculture, Fisheries and Food (MAFF) has carried out research at Carlton since the late 1950s (Murton 1965). The principal study species was woodpigeon, but from 1958 to 1966 Dr Ron Murton, assisted by various fieldworkers, also collected incidental data on Stock Doves and Turtle Doves in the course of the Woodpigeon fieldwork. This resulted in the only detailed studies of Turtle Dove ecology in the UK (Murton *et al.* 1964, Murton 1968). Given the importance of these early studies, it seemed appropriate to re-survey the Carlton area for Turtle Doves, using the same methodology as Murton for compatibility. Since the 1960s, MAFF has continued funding work on Woodpigeons, including ongoing research at Carlton (Murton 1965, Inglis *et al.* 1994a, Inglis *et al.* 1994b). This work is currently directed by Dr Ian Inglis (CSL), who has been very helpful in allowing us to access the monitoring data on land use and in putting us in touch with Mr A.J. Isaacson, now retired but one of Murton's original fieldworkers from the 1960s.

The study site at Carlton is situated near Newmarket, Cambridgeshire, and occupies an area of approximately 1000 ha. About 95% of the site is used for agricultural purposes, with cereal production accounting for over 60% of the land area. Pasture occupies about one fifth of the study site with the remainder of the land being under legumes and rape. The landscape is slightly undulating and is interspersed with hedgerows and some small patches of woodland. A description of the site during the 1960s is provided by Murton (Murton 1965) and an account of changes in land use during the period 1961-1986 is given by Inglis *et al.* (1994b). In addition to the Carlton site, studies of Woodpigeon breeding success are also carried out at a small area of woodland at the nearby village of Six Mile Bottom, where a number of Turtle Dove nests were also found and monitored.

7.2 Methods

The methodology described below is the same as that used during the original fieldwork at Carlton in the 1960s. Mr A.J. Isaacson, who was involved in that original fieldwork, very kindly agreed to carry out the repeat surveys at Carlton in 1999 and 2000.

7.2.1 General methods

The entire study site was surveyed for the presence of territorial Turtle Doves once every two weeks from late April to early September. Mr A.J. Isaacson drove along all roads within and surrounding the site, stopping at 36 observation points. From these observation points he sampled all fields with binoculars and listened for the song of Turtle Doves. In addition, he walked a route taking him past a length of hedgerow and around Carlton wood. He recorded observations of Turtle Doves on maps.

Nest searching was carried out every two weeks between late April and early September around the perimeter of Carlton Wood, on a 500-m length of hedgerow leading up to Carlton Wood and at a 1.3-ha area of woodland at Six Mile Bottom. The "cold-searching" method was used, whereby all suitable bushes were systematically checked for the presence of nests. The fate of all nests found was recorded.

Whilst carrying out the territory mapping, all observations of non-territorial and feeding birds were mapped and the habitat that they were using was recorded.

7.2.2 Crop and habitat information 1960s to 1990s

Crop and habitat information for the entire Carlton study site has been collected each month since the late 1950s by MAFF, and has been kindly made available to this study.

7.3 Results

7.3.1 Territory density

No territorial behaviour was recorded for Turtle Doves at Carlton during the 1999 and 2000 breeding seasons.

7.3.2 Breeding success

No nests were located at Carlton during the 1999 and 2000 breeding seasons.

7.3.3 Habitat use

Turtle doves were recorded on the Carlton study site on 5 occasions in both 1999 and 2000. These observations are summarised in Table 7.1. Two observations were of a feeding bird, on rape stubble in both cases. All sightings except one were comparatively late and most probably represented birds that had completed breeding and were preparing for migration. The early sighting could have been a spring migrant.

Table 7.1 Observations of Turtle doves on the Carlton study site during 1999-2000

Observation	Date	Behaviour	Number of birds
1	05/08/99	Perched in an ash tree	1
2	05/08/99	Feeding on rape stubble	1
3	23/08/99	Perched in a hawthorn	4
4	23/08/99	Perched on telegraph wires	1
5	08/09/99	Perched on telegraph wires	1
1	09/05/00	Flushed from concrete area	1
2	07/07/00	Perched	1
3	24/07/00	Flying over	1
4	21/08/00	Feeding with Woodpigeons on ploughed rape stubble	1
5	07/09/00	Perched on electric cables	2

7.3.4 Crop and habitat information 1960s to 1990s

Crop information for the Carlton study site between the 1960s and 1990s is summarised and shown in relation to habitat use in Table 4.8. The principal change in land use at Carlton has been the switch from spring-sown to winter-sown cereals, an increase in the planting of Oil-seed Rape and the reduction in the use of clover leys and hay fields. In addition to the changes in land use, agricultural practices have changed, for example cereals are no longer stooked.

7.4 Discussion

No breeding Turtle Doves were recorded at the Carlton study site in 1999 and 2000 and only two observations of a feeding bird were noted. In the 1960s, at least six pairs were recorded as breeding each year and numerous observations were made of feeding birds. In the intervening period, between the early 1960s and late 1990s, there have been numerous changes in land use and management techniques, which have particularly affected Turtle Dove feeding areas. Fields of clover leys and hay, which were the main Turtle Dove feeding areas in the 1960s during the early part of the breeding season, have almost disappeared. Later in the breeding season the doves fed on fields with stooked wheat and weedy pea fields during harvest. Changes in crop husbandry and harvesting techniques have resulted in these feeding sites no longer being available today (O'Connor & Shrubb 1986).

CHAPTER 8

HABITAT AVAILABILITY AND HABITAT USE BY TURTLE DOVES BETWEEN 1965 TO 1995: AN ANALYSIS OF COMMON BIRDS CENSUS DATA

8.1 Introduction

The results from Chapter 3 identified hedge, scrub and woodland edge as being important habitat requirements within Turtle Dove territories. It appeared that the availability of these habitats was one of the main factors determining Turtle Dove density. Together with a range of other habitats, the availability of hedges, scrub and woodland have decreased or changed over the last 40 years (Barr *et al.* 1993) and it is likely that this has influenced Turtle Dove density. To put the results of Chapter 3 into a national context, and to investigate how temporal changes in habitat availability may have affected habitat use and Turtle Dove density over the last 40 years, I examine the bird and habitat data held within the BTO's CBC scheme.

The CBC (Marchant *et al.* 1990) is a scheme based on territory mapping that provides the most comprehensive and long-running population data set for birds, including the Turtle Dove, in the UK. In addition to the annual spatial bird data, the CBC also provides information on habitats and land use.

8.2 Methods

8.2.1 The Common Birds Census (CBC) scheme

Until recently the CBC has been the main scheme that monitored bird populations in the UK. The CBC uses annual censuses of fixed areas of land (known as plots) to record the number of bird territories present. Annual changes in territory numbers on the CBC plots are used to provide a measure of bird population fluctuations within the UK. The CBC started in 1962 and initially considered only farmland plots, but in 1964 it was extended to include woodland plots as well. After 2000, it was replaced by another more comprehensive and less labour-intensive survey known as the Breeding Bird Survey (BBS). A full description of the history of the CBC and the methodology involved is provided by Marchant *et al.* (1990) and is summarised is here.

Each CBC plot is surveyed between eight and ten times during the breeding season. The position of all birds seen or heard on each visit are plotted onto a large-scale map (1:2500) using a range of different codes for each species and its activity. At the end of the breeding season the information collected on each visit is combined and used to define the number of breeding territories present. As well as recording bird data, observers also collect habitat and land use information, ideally every year, but as a minimum for each year in which a habitat change occurs.

The CBC plots fall into one of two broad categories, namely farmland and woodland. Farmland plots include all types of arable, horticultural and grazing land and should be between 40 and 60 ha in size. Small woods, which do not exceed 10% of the plot area, may be included. Woodland plots include all kinds of semi-natural broad-leaved and mixed woodlands, but exclude parkland and even-aged plantations of conifers. Woodland plots should be at least 10 ha. In all, 200 to 300 plots are censused each year throughout the UK, approximately equally divided between farmland and woodland, and on average each plot is censused for seven years (Marchant *et al.* 1990).

Traditionally there has been a bias for CBC plots to be situated in the south-east of England, near the main centres of human population (i.e. observers) and as such they are not necessarily truly representative of the distribution of many species of bird. However, given the distribution of Turtle Doves within Britain, this bias is minimal.

8.2.2 CBC Plot selection

CBC plots used in this analysis were selected from both the farmland and woodland category. To use the most appropriate and reliable data, only plots that fulfilled the following criteria were selected:

- The plot was surveyed for at least ten years.
- Surveying of the plot commenced before 1975 (although in two cases this

was extended to 1979) and finished no earlier than 1990 (although in one case this was lowered to 1979).

- Turtle dove territories were recorded on at least five occasions during the survey period of each plot.
- Habitat and crop information were available for at least ten years of the survey period.

These criteria were satisfied in full by 27 plots and partially by three. This was out of a total of more than 1500 CBC plots. The plots selected were split equally between farmland and woodland. However, even for the selected plots, gaps in the dataset exist because several bird, habitat or crop maps could not be found in the BTO archives, or in some years the plots were not surveyed.

Very few of the plots were surveyed during the early years of the CBC (1962-64) and also very few supported Turtle Dove territories after 1995. To overcome the problem of small sample size in these early and late years, which may have produced spurious results, the analysis was limited to data collected between 1965 and 1995. Nevertheless, the data available for analysis still represent approximately 750 plot-years of data and are considered sufficient for analysis.

8.2.3 Data extraction

All available habitat and bird information was extracted from the paper CBC maps and entered onto digital maps stored within the computer-based GIS (Mapinfo Corp. 1999). Information on the bird locations, habitat, cropping and hedges were stored on separate maps. The information for each year was stored as a separate layer. Data extracted from the GIS were used to calculate four measures of habitat quality on the farmland plots and two on the woodland plots.

On the farmland plots a measure of overall habitat quality was derived by calculating a habitat diversity index, using the Shannon-Weaver formula (Fowler *et al.* 1998). The habitat diversity index was calculated using the proportions of each of 31 crop and habitat types. A measure of nesting habitat availability was given by a "hedginess" index, calculated as a ratio of hedge length, woodland and scrub edge (m) to plot area (ha). Two measures of food availability were obtained by classifying habitats as either "natural" food, based on information supplied by Murton *et al.* (1964) and "artificial" food based on information provided in Chapter 4. The natural food category included all grassland, but excluded intensive managed grassland such as improved pasture and silage. The artificial food category included all cereal crops, Linseed and Oil-seed Rape. On the woodland plots a hedginess index was calculated as a ratio of woodland/scrub edge (m) to plot area (ha). A woodland habitat diversity index was calculated using the proportions of the four major habitat groups (woodland, scrub, grass and other).

8.2.4 Statistical analysis

A Poisson regression (generalised linear model with Poisson error, logarithmic link function and ln(plot area) as offset) of territory number against year and plot as factors was used to assess the effect of year on Turtle Dove abundance after taking into account plot size and plot turnover on both the farmland and woodland plots. The regression model was fitted using Genstat 4.2 (Genstat committee 2000), and the coefficients used to produce adjusted means i.e. annual indices (and s.e.) of territory density standardised to 100 ha for the period 1965 to 1995. A similar procedure based on two-way ANOVAs involving year and plot factors was adopted to produce annual index values for each of the measures of habitat quality. Linear regression was used to test for trends over time in the annual index of Turtle Dove density (log-transformed) and in the annual indices of each of the habitat variables, for farmland and woodland plots separately. The analysis of habitat variables was carried out on 14 of the farmland plots as no hedgerow information was available for plot 209. To investigate the relationship between the temporal changes in Turtle Dove density and in habitat availability, the analysis proceeded in two steps. First, for each plot, linear trend coefficients were calculated from regressions of annual territory density ($\ln(x+1)$-transformed) and for each of the habitat variables against time. The coefficients for territory density, representing plot-specific changes in abundance over time, were then related to the coefficients of change in the habitat variables using simple regression weighted by the number of years each plot was surveyed. For the farmland plots, change in bird density was compared to changes in hedginess index, the proportion of plot area under artificial and natural food crops and the habitat diversity index. On the woodland plots, change in Turtle Dove densities was investigated in relation to changes in habitat diversity and hedginess index.

Compositional analysis (Aitchinson 1986) was used to investigate habitat availability and use on the farmland and woodland CBC plots (Aebischer *et al.* 1993a, b). A measure of habitat use was derived by calculating the proportion of all habitats within a 50-m buffer around bird registrations from within each territory. The overall proportion of each habitat on the whole plot represented habitat availability. To simplify the analysis and to overcome the problems associated with large numbers of habitat categories (Aebischer *et al.* 1993a), habitats were classified into five major groups for the farmland plots (Cereals, Break crops, Grassland, Woodland and Other) and four groups for woodland plots (Grassland, Scrub, Woodland and Other). For both use and availability, the proportion of each habitat group was converted to a logratio using the "other" habitat category as the denominator. Temporal changes in habitat availability were investigated using a MANOVA on the logratios for availability to test for the effect of year after adjusting for the effect of plot (Aebischer *et al.* 1993a, b). MANOVA was also used to investigate whether habitat use was random with respect to availability by analysing the logratio differences between habitat use and availability (Aebischer *et al.* 1993a, b). To investigate if relative habitat use had changed before and after agricultural intensification, the years 1965-75 were categorised as pre-intensification, the years 1985-95 as post-intensification and MANOVA used to compare relative use in the two periods.

8.3 Results

8.3.1 Study plots

The locations of the CBC plots used for the analysis are shown in Figure 8.1 and information about each of the CBC plots is summarised in Table 8.1. The average size of the woodland plots was 30.9 ± 5.2 ha, which was significantly smaller than the average of 88.1 ± 12.3 ha for farmland plots (t_{28} = 4.29, P < 0.001). This is in accordance with the plot selection requirements of the CBC scheme (Marchant *et al.* 1990).

8.3.2 Territory density

The mean density of Turtle Doves on the farmland plots during the period 1965 to 1995 was 3.45 ± 0.98 pairs per km^2 (range 0.29-14.25) (Table 8.2). This was significantly lower than the woodland plots, where mean density was 18.61 ± 6.43 territories per km^2 (range 1.11-93.38) (t_{28} = 2.33, P = 0.027; Table 8.3). On both the farmland and woodland plots there was a significant decrease in mean territory density during the period 1965 to 1995 (Farmland r_{29} = -0.763, P < 0.001; woodland r_{29} = -0.915, P < 0.001; Figure 8.2), corresponding to annual rates of decline of –3.3% and –4.3% respectively.

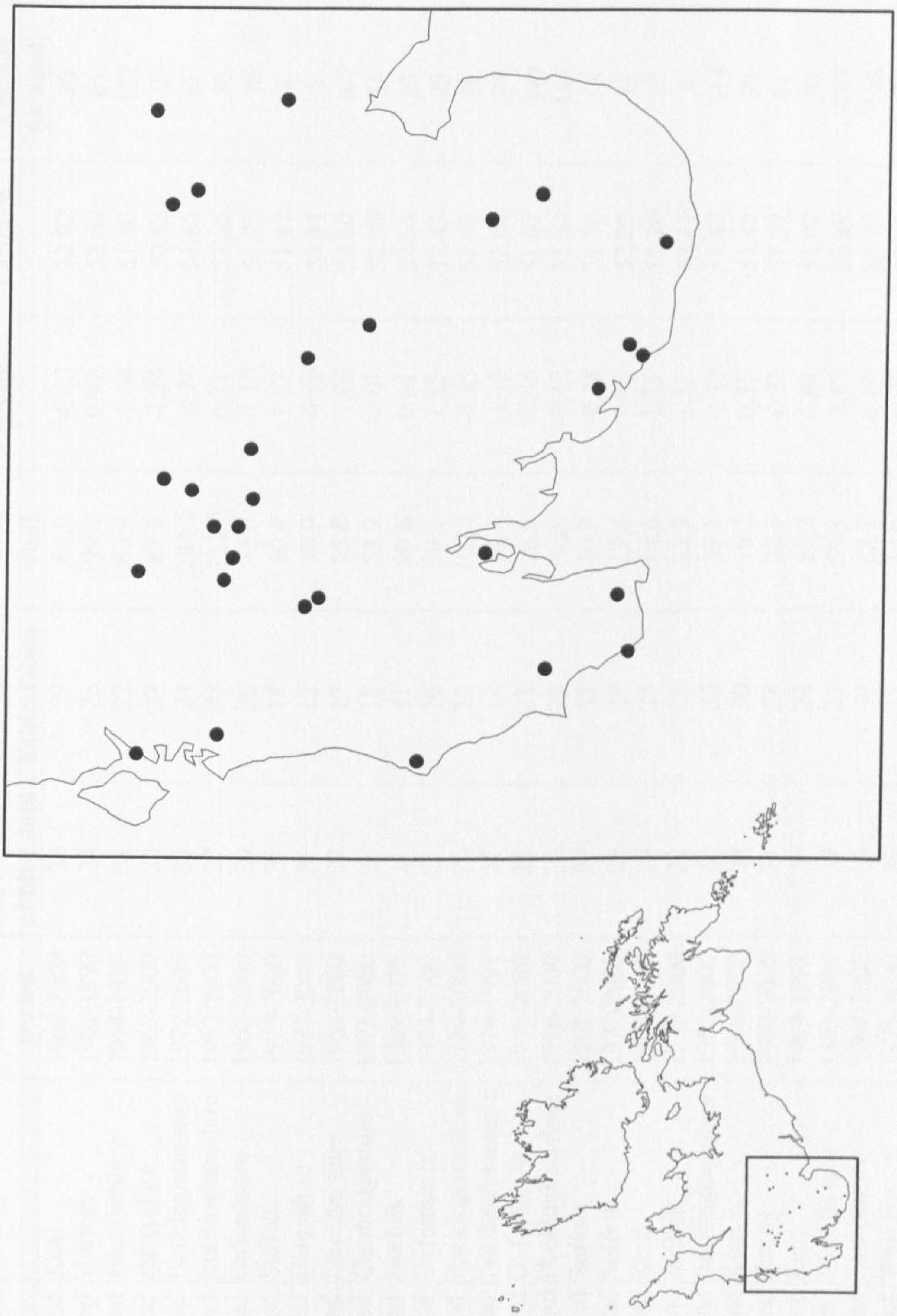


Figure 8.1 The location of the CBC plots used for this study

Table 8.1 Summary information for the CBC plots used for this study.

Plot number	Type	County	Survey period	No. of years of bird data	No. of years of habitat data	Area (ha)	Longitude	Latitude	Altitude (m amsl)
9	Farmland	Kent	1965-2000	36	29	61.9	-0.43	52.92	30
59	Farmland	Norfolk	1962-1990	34	26	99.7	0.92	52.60	61
62	Farmland	Hertfordshire	1964-1990	31	22	63.9	-0.64	51.80	122
146	Farmland	Hampshire	1969-2000	20	27	87.0	-1.24	50.82	2
209	Farmland	Buckinghamshire	1972-2000	23	24	240.5	-0.74	51.45	61
251	Farmland	Buckinghamshire	1962-2000	27	28	112.0	0.71	51.55	30
304	Farmland	Oxfordshire	1962-2000	20	26	75.0	-1.10	51.70	76
318	Farmland	Suffolk	1975-2000	26	18	60.4	1.17	51.97	8
319	Farmland	Hampshire	1977-2000	21	17	70.9	-0.96	50.84	5
364	Farmland	Leicestershire	1964-2000	37	17	95.6	-1.06	52.60	107
415	Farmland	Cambridgeshire	1973-2000	26	15	53.9	-0.01	52.20	54
460	Farmland	Norfolk	1969-1979	11	11	90.6	0.64	52.53	23
463	Farmland	Oxfordshire	1974-2000	21	16	29.6	1.55	52.43	23
881	Farmland	Buckinghamshire	1974-2000	25	22	107.1	-0.85	51.55	30
957	Farmland	Northamptonshire	1974-1991	17	18	72.8	-1.13	52.90	34
44	Woodland	Oxfordshire	1975-2000	21	21	26.5	-0.95	51.67	198
46	Woodland	Buckinghamshire	1976-2000	25	20	6.2	-0.62	51.64	152
84	Woodland	Suffolk	1961-2000	37	31	19.2	-0.38	51.30	58
149	Woodland	Suffolk	1972-2000	29	27	19.8	1.43	52.07	17
395	Woodland	Kent	1971-2000	29	25	10.6	1.25	51.30	12
450	Woodland	Suffolk	1979-2000	22	18	22.7	1.35	52.11	4
531	Woodland	Buckinghamshire	1961-2000	40	30	33.1	-1.23	51.42	114
555	Woodland	Kent	1966-2000	29	30	16.2	0.55	51.45	39
647	Woodland	Surrey	1968-2000	30	28	22.5	-0.31	51.32	61
746	Woodland	Kent	1969-1992	7	24	37.7	0.86	51.07	30
837	Woodland	West Sussex	1963-2000	37	31	59.3	-0.83	50.89	137
838	Woodland	East Sussex	1964-2000	25	30	62.1	0.19	50.79	108
882	Woodland	West Sussex	1975-2000	26	21	14.9	-0.80	50.93	130
961	Woodland	Bedfordshire	1973-1994	21	21	74.5	-0.34	52.09	52
991	Woodland	Kent	1976-2000	29	25	37.7	-1.29	51.12	76

Table 8.2 *Turtle dove (territories/km²) density on the farmland CBC plots during the period 1965-1995. Blank cells indicate that no data was collected/available.*

	Plots														
Year	**9**	**59**	**62**	**142**	**209**	**251**	**304**	**318**	**319**	**364**	**415**	**460**	**463**	**881**	**957**
1965	1.62	7.00	0.00				0.00			2.09					
1966	3.23	12.04	0.00			0.89	0.00			1.05					
1967	3.23	9.03	0.00			0.00	0.00			0.00					
1968	3.23	7.02	1.62			3.57	0.00			1.05					
1969	1.62	8.03	1.57	0.00		3.57	0.00			3.14		7.73			
1970	3.23	7.02	9.72	0.00		2.68	0.00			2.09		12.14			
1971	3.23	11.04	8.10	0.00		1.78	1.34			1.05		13.24			
1972	1.62	9.03	1.62	0.00	0.00	0.94	0.00			1.05		15.45			
1973	3.23	7.02	1.57	4.60	1.34	0.00	4.00			1.05		22.07			
1974	1.62	3.01	3.15	6.90	1.82	0.94	4.00			0.00	1.85	12.14		1.25	
1975	4.85	7.03	1.57	3.45	0.91	0.00	1.33	6.73		3.14	1.85	16.56	6.62	1.25	1.39
1976	4.85	6.02	0.00	8.04	2.19	0.00	5.34	5.05		1.05	1.85	13.24	6.62	0.00	2.78
1977	4.86	7.03	1.57	8.04	1.75	1.87	0.00	5.05	2.47	2.09	3.71	13.24	16.56	1.15	4.17
1978	9.73	4.02	1.57	6.90	4.09	0.89	1.33	5.05	1.23	0.00	1.85	12.14	6.62	0.00	1.39
1979	4.86	4.02	0.00	9.19	2.61	0.94	1.33	5.05	2.47	2.09	1.85	18.77	6.62	0.00	4.17
1980	8.10	8.03	0.00	5.75	2.73	0.98	0.00	3.37	3.70	1.05	5.56		3.31	0.00	2.78
1981	0.00	7.03	1.57	2.30	2.34	0.98	0.00	5.05	2.47	1.05	1.85		9.93	1.08	2.78
1982	3.24	4.02	0.00	5.75	1.66	0.00	0.00	3.37	2.47	0.00	1.85		3.31	1.05	0.00
1983	0.00	5.02	3.15	8.04	1.66	0.00	0.00	5.05	2.47	2.09	7.42		19.87	0.00	0.00
1984	0.00	4.02	0.00	6.90	2.19	0.00	0.00	3.37	3.70	1.05	0.00		9.93	0.00	0.00
1985	0.00	5.02	1.57	1.15	1.05	0.00	0.00	5.05	3.70	1.05	0.00		16.56	0.00	0.00
1986	0.00	7.03	1.57	5.75	2.08	0.98	1.33	5.05	3.70	1.05	1.85		9.93	0.00	0.00
1987	0.00	8.03	0.00	4.60	0.83	0.93	1.33	1.68	1.23	1.05	1.85		6.63	0.00	0.00
1988	0.00	4.02	1.57	4.60	0.00	0.00	0.00	3.96	1.23	0.00	0.00		9.93	0.00	0.00
1989	0.00	2.01	0.00	2.30	0.00	0.00	0.00	6.61	1.23		1.85		3.31	0.00	
1990	0.00	2.01	1.57	4.60	2.08	0.00	0.00	8.41	1.23		0.00		6.62	0.00	
1991	0.00			6.90		0.00	0.00	6.73	1.23		0.00		6.62	0.00	
1992	0.00			2.30		0.00	0.00	9.91	0.00		0.00		6.60	0.00	
1993	1.62			1.15		0.00	0.00	8.26	0.00		0.00		3.31	0.00	
1994	0.00			1.15			0.00	8.26	0.00		0.00		9.94		
1995	0.00			0.00			0.00	3.30	0.00		0.00		6.63		
Mean	2.19	6.33	1.66	4.09	1.65	0.78	0.69	5.45	1.82	1.22	1.60	14.25	8.36	0.29	1.39
s.e.	0.45	0.50	0.46	0.58	0.24	0.20	0.25	0.45	0.30	0.19	0.41	1.16	0.99	0.12	0.44

Table 8.3 Turtle dove (territories/km^2) density on the woodland CBC plots during the period 1965-1995. Blank cells indicate that no data was collected/available.

	Plots														
Year	**44**	**46**	**84**	**149**	**395**	**450**	**531**	**555**	**647**	**746**	**837**	**838**	**882**	**961**	**991**
1965			10.43				6.04				5.06	0.00			
1966			0.00				9.06				1.69				
1967			5.21				9.06				1.69				
1968			0.00				9.06		4.44		3.37				
1969			10.43				6.04		4.44		5.06				
1970			20.86				9.06	98.31	0.00	18.56	3.37				
1971			20.86		64.32		6.04	115.32	0.00	21.21	5.06	1.61			
1972			10.43	10.12	88.44		9.06	145.57	0.00		1.69	0.00			0.00
1973			5.21	20.25	95.70		6.04		8.88		3.37	1.61			0.00
1974			0.00	15.19			3.02		8.88		3.37			25.48	0.00
1975	3.96		0.00	20.25	95.70		3.02	41.59	8.88		1.69		0.00	34.74	0.00
1976	3.96	0.00	5.21	35.43	95.70		0.00	56.72	4.44		1.69		6.74	72.75	0.00
1977	3.96	36.82	0.00	35.43	63.80		3.02	49.15	4.44		3.37		0.00	47.29	0.00
1978	0.00	73.64	0.00	35.43	87.72		0.00	24.58	8.88		3.37		0.00	43.65	0.00
1979	0.00	18.41	0.00	30.37	111.64	19.90	6.04	39.70	4.44		1.69	3.22	0.00	47.29	0.00
1980	0.00	36.82	0.00	60.74	103.67	19.90	3.02	51.04	4.44		3.37	9.67	0.00	43.65	0.00
1981	3.96	36.82	0.00	60.74	95.70	14.92	0.00	58.61			1.69	6.44	6.74	18.53	0.00
1982	3.96	18.41	0.00	40.49	95.70	19.90	3.02	69.95	17.75		0.00	4.83	0.00	17.37	0.00
1983	0.00	36.82	0.00	40.50	87.72	19.90	0.00	52.94	8.88		3.37	6.44	0.00	5.79	0.00
1984	0.00	18.41	0.00	40.50	119.62	39.79	3.02	32.14	13.32		1.69	4.83	0.00	5.79	2.57
1985	0.00	18.41	0.00	60.76	63.80	39.79	0.00	37.81	13.32		3.37	0.00	0.00	9.26	0.00
1986	0.00	18.41	0.00	40.50	95.70	44.76	3.02	37.81	17.75		1.69	0.00	0.00	4.63	2.57
1987	0.00	0.00	0.00	35.44	94.64	54.71	3.02	35.92			5.06	1.61	6.74	2.32	0.00
1988	0.00	18.41	0.00	25.31	95.70	29.84	3.02	28.36		13.25	0.00	1.61	6.74	6.95	0.00
1989	3.96	0.00	0.00	25.31	119.62	49.74	3.02	24.58	0.00	15.91	1.69	1.61	0.00	2.32	5.14
1990	0.00	36.82	0.00	20.25	119.62	29.84	0.00	15.12	0.00	7.95	1.69	1.61	6.74	6.95	2.57
1991	0.00	36.82	0.00	20.25	71.77	39.79	0.00	13.23	8.88	2.65	3.37	0.00	0.00	2.32	0.00
1992	0.00	18.41	0.00	20.25	87.72	59.68	0.00	20.80	8.88	2.65	1.69	0.00	6.74	3.47	2.66
1993	0.00	18.40	0.00	10.12	95.70	24.87	0.00	18.91	4.44		1.69	3.22	6.74	1.16	0.00
1994	0.00	0.00	0.00	5.06	103.67	24.87	0.00	9.45	0.00		0.00	1.61	13.47	2.32	8.28
1995	0.00	18.38	0.00	5.06	87.72	34.82	0.00	5.67	4.44		3.37	4.83	13.47		2.76
Mean	1.13	23.01	2.86	29.74	93.38	33.35	3.41	45.14	6.39	11.74	2.56	2.61	3.53	19.24	1.11
s.e.	0.40	3.98	1.05	3.34	3.26	3.27	0.59	6.92	1.06	2.83	0.26	0.58	1.00	4.53	0.43

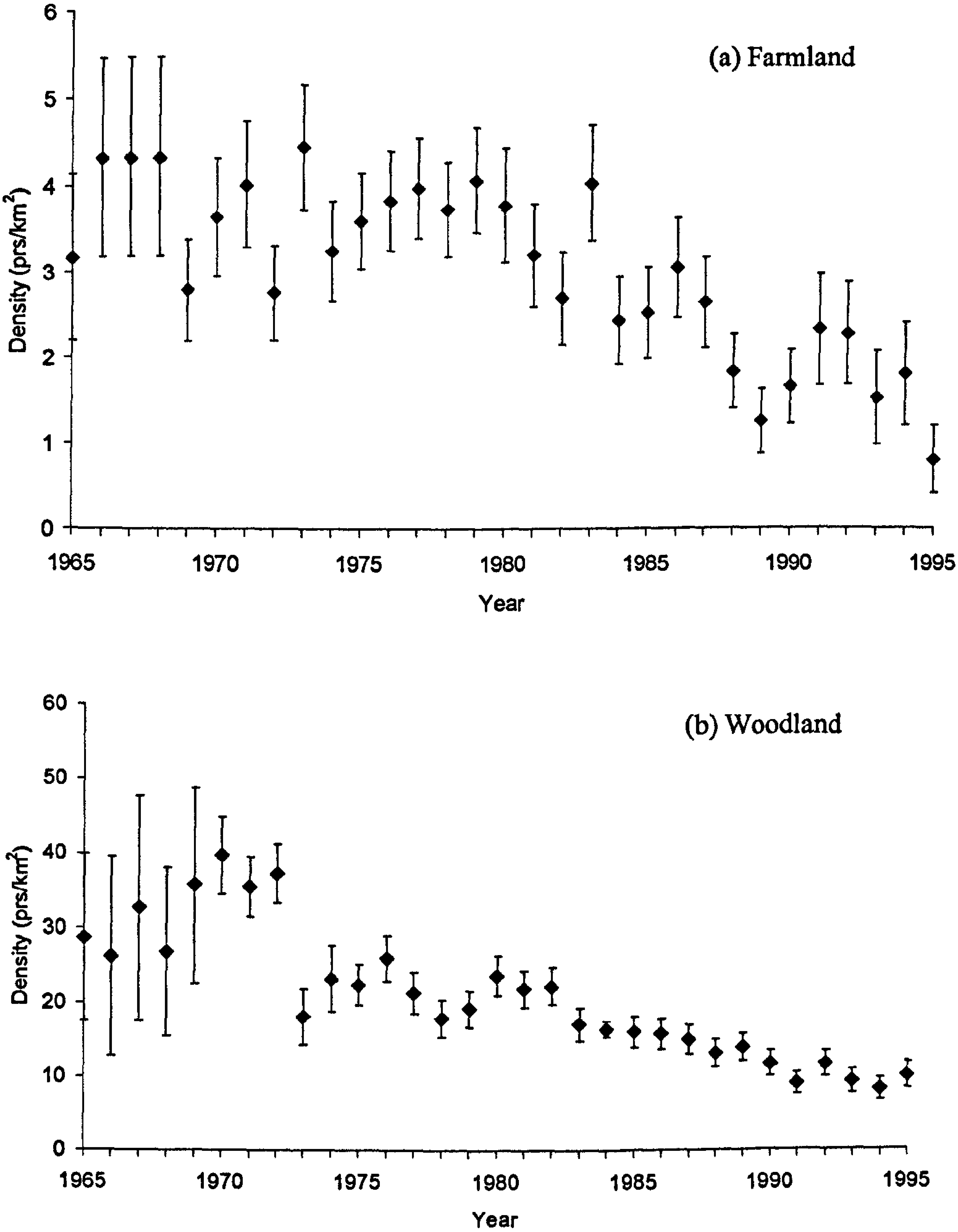


Figure 8.2 Annual index of Turtle Dove density (pairs/km^2) on the (a) farmland and (b) woodland CBC plots during the period 1965 to 1995. Error bars represent 1 standard error.

8.3.3 Habitat availability

Overall habitat availability

There was a significant difference in habitat availability, expressed as the proportion of each of the main habitat categories within each CBC plot, between the individual plots both within farmland ($\Lambda = 0.123$, $F_{56,1052} = 13.41$, $P < 0.001$) and woodland ($\Lambda = 0.000$, $F_{42,985} = 2219953$, $P < 0.001$). However, there was no significant difference in habitat availability between years within farmland ($\Lambda = 0.676$, $F_{120,1075} = 0.93$, $P = 0.692$) or woodland ($\Lambda = 0.730$, $F_{90,994} = 1.22$, $P = 0.085$).

Habitat diversity

The mean habitat diversity index on the farmland plots was 1.09 ± 0.02 (range 0.05–1.98), and on the woodland plots 0.55 ± 0.01 (range 0–1.07). There was a significant decrease in the habitat diversity of the farmland plots during the study period 1965 to 1995 ($r_{29} = -0.406$, $P = 0.023$; Figure 8.3a), whereas the index increased significantly on the woodland plots ($r_{29} = 0.609$, $P < 0.001$; Figure 8.3b).

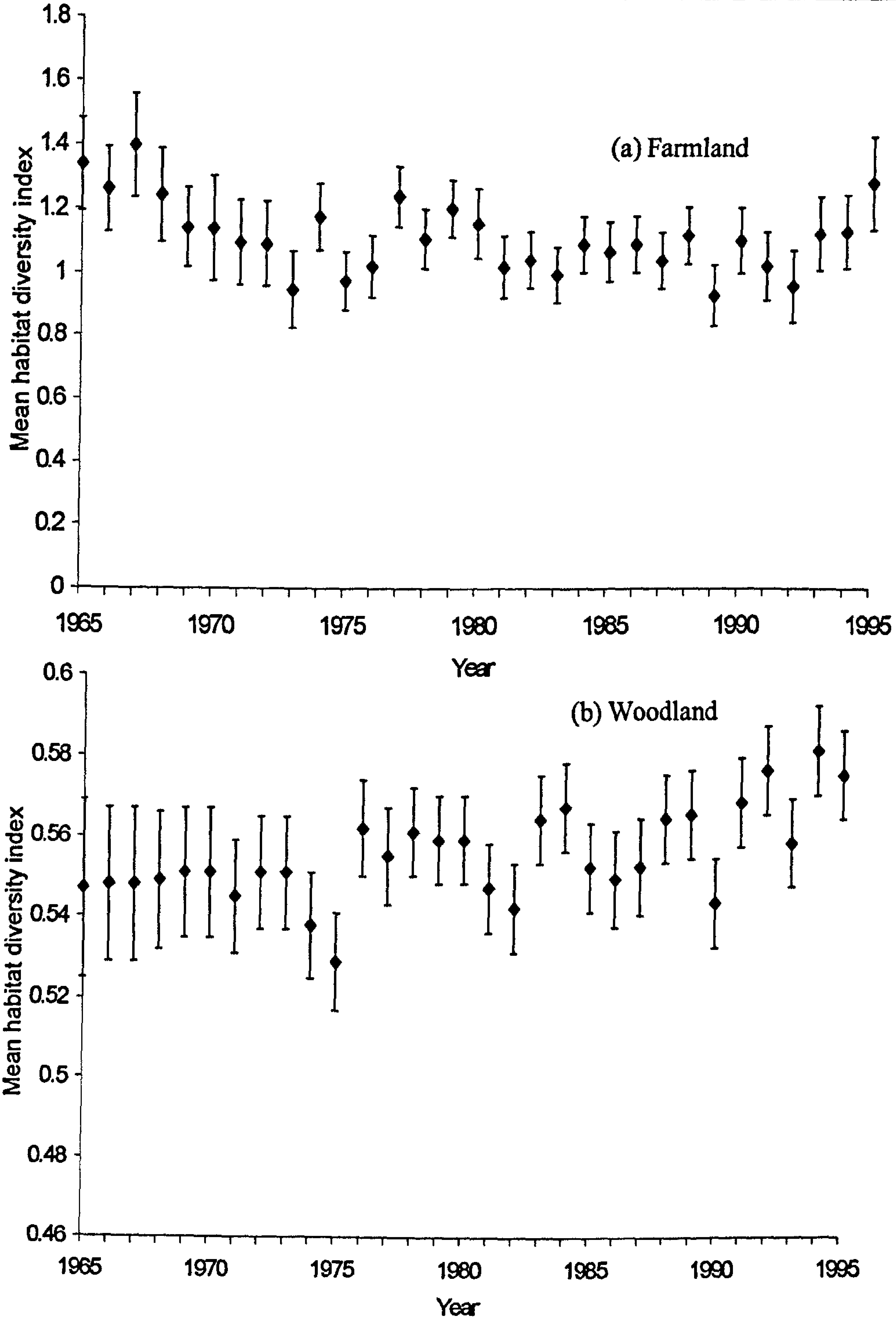


Figure 8.3 Annual index of diversity (see text) on the a) farmland and b) woodland CBC plots during the period 1965 to 1995. Error bars represent 1 standard error.

Nesting habitat

On the farmland plots the mean index of hedginess during the period 1965-95 was 79.43 ± 1.77 (range 24.03-206.9) m of hedgerow and wood/scrub edge per ha, and on woodland plots it was 186.25 ± 4.11 (range 80.46 – 328.64) m of woodland/scrub edge per ha (Figure 8.4). The amount of nesting habitat available to Turtle Doves on farmland decreased from the early 1960s to the late 1980s, after which it increased; however the overall hedginess of the farmland CBC plots showed no overall linear trend (r_{29} = 0.045, P = 0.799; Figure 8.4a). On the woodland plots the index decreased significantly during the same period (r_{29} = -0.405, P = 0.024; Figure 8.4b).

Food-producing habitats

In terms of surface area, the mean proportion of the farmland plots that supported habitats producing natural food during the period 1965-95 was 0.28 ± 0.01 (range 0.0–0.91) (Figure 8.5a). There was a significant annual decrease in the proportion of these habitats during the study period (r_{29} = -0.721, P < 0.001; Figure 8.5a). The decrease in the proportion of habitats producing natural food was replaced by a significant increase in the proportion of habitats producing artificial food (r_{29} = 0.666, P < 0.001; Figure 8.5b). The mean proportion of the farmland plots that supported habitats producing artificial food was 0.44 ± 0.02 (range 0-0.99) (Figure 8.5b)

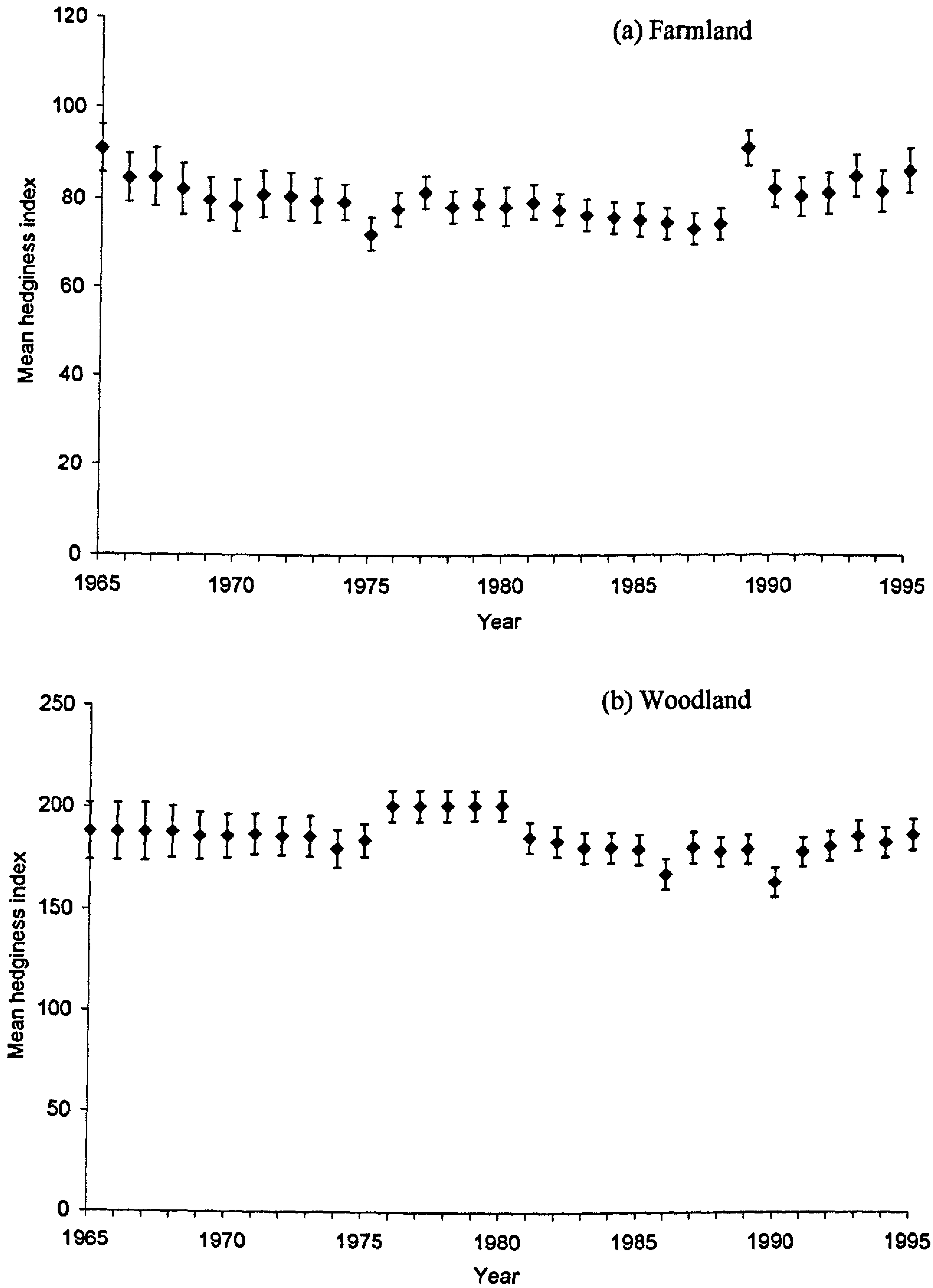


Figure 8.4 Annual index of hedginess (see text) on the a) farmland and b) woodland CBC plots during the period 1965 to 1995. Error bars represent 1 standard error.

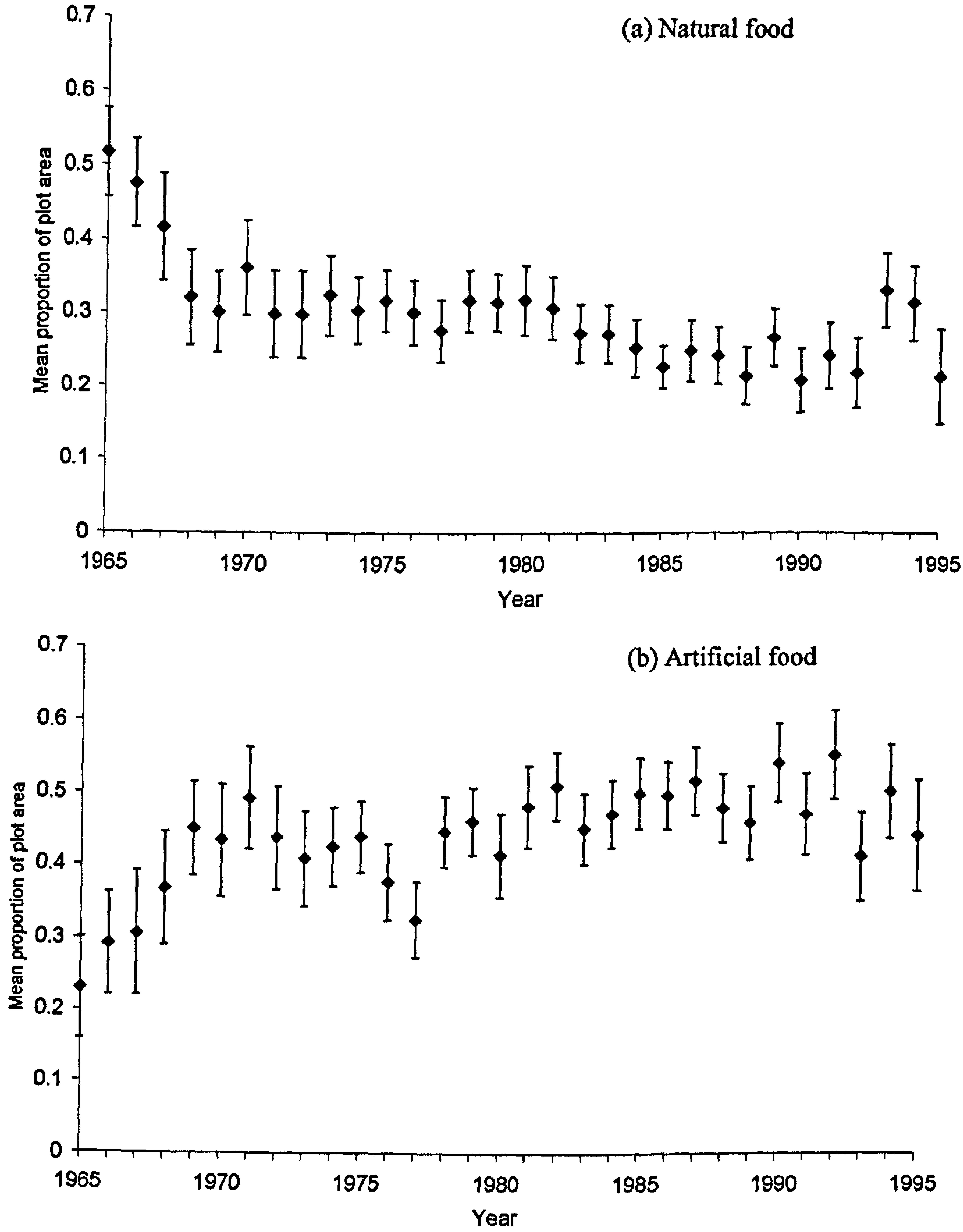


Figure 8.5 Annual index of the proportion of plot area producing a) natural and b) artificial food on the farmland CBC plots during the period 1965 to 1995. Error bars represent 1 standard error.

8.3.4 Turtle dove density in relation to habitat availability

On the farmland plots, there was a significant positive correlation between change in annual territory density and change in hedginess of the CBC plots (Table 8.4). There was no significant correlation with any of the other habitat variables (habitat diversity, proportion of plot area supporting habitats producing natural and artificial food).

On the woodland plots, the change in annual territory density was not significantly correlated with change in either against change in habitat diversity or the woodland/scrub edge index (Table 8.4).

Table 8.4 Results from regression analysis relating changes in Turtle Dove density to changes in hedginess index, habitat diversity index and on the farmland plots changes in the proportion of the plots producing natural and artificial food.

Effect	Correlation coefficient	*P* value
Farmland plots		
Hedge index	$r_{12} = 0.585$	0.028
Habitat diversity index	$r_{12} = 0.405$	0.151
Natural food	$r_{12} = 0.265$	0.361
Artificial food	$r_{12} = -0.450$	0.106
Woodland plots		
Hedge index	$r_{13} = 0.325$	0.238
Habitat diversity index	$r_{13} = 0.00$	1.000

8.3.5 Habitat Use

Compositional analysis found no significant between-year difference in habitat use relative to availability on the farmland CBC plots after taking plot differences into account ($\Lambda = 0.448$, $F_{120,531} = 0.992$, $P < 0.509$). Nor did relative habitat use on the CBC plots vary significantly between the periods of pre- and post-agricultural intensification ($\Lambda = 0.989$, $F_{4,95} = 0.262$, $P = 0.902$). As a result, for each plot the annual data were replaced by an overall mean proportion of each habitat category across all years, and the data analysed using plot as the unit for analysis.

Turtle dove habitat use on the farmland plots differed significantly from expected based on to availability ($\Lambda = 0.221$, $F_{4,11} = 9.704$, $P < 0.001$). Thus Turtle Dove territories were not established at random on the CBC plots. The ranking matrix of relative habitat use (Table 8.5) indicated that woodland was the most used habitat and that habitats categorised as "Other" was the least used (Figure 8.5).

On the woodland CBC plots there was a significant between-year difference in habitat use relative to availability ($\Lambda = 0.165$, $F_{90,351} = 3.216$, $P < 0.001$). In addition, relative habitat use on the CBC plots varied significantly between the periods of pre- and post-agricultural intensification ($\Lambda = 0.923$, $F_{4,95} = 2.930$, $P = 0.037$).

Table 8.5 Ranking matrix for Turtle Doves on the farmland CBC plots based on comparing the habitat composition within Turtle Dove territories with that available on the plots (all years pooled). The positive sign indicates that the row habitat was used more than the column habitat, relative to availability, and the minus sign means the opposite. A triple sign indicates that the difference was significant at $P < 0.05$.

	Cereals	**Grass**	**Other**	**Break crops**	**Wood**	**Rank**
Cereals		---	+	-	---	1
Grass	+++		+	+	---	3
Other	-	-		-	---	0
Break crops	+	-	+		-	2
Wood	+++	+++	+++	+		4

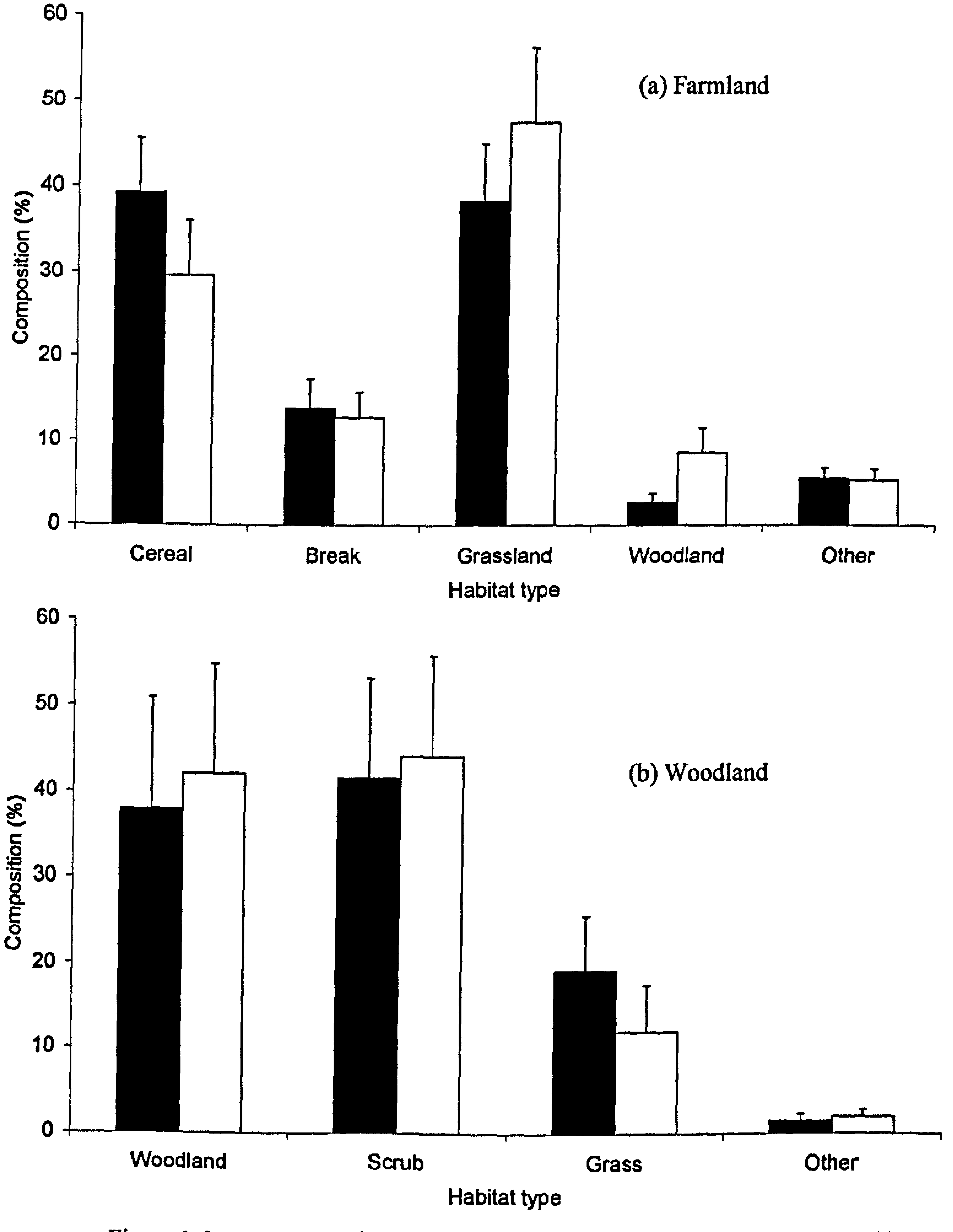


Figure 8.6 Mean habitat availability (black bars) on the a) farmland and b) woodland CBC plots and mean composition of Turtle Dove territories (white bars), averaged across years. Error bars represent 1 standard error

8.4 Discussion

The mean density of Turtle Doves on the farmland CBC plots was 3.4 territories per km^2 and 18.6 territories per km^2 on the woodland CBC plots during the period 1965 to 1995. The values for farmland are lower than those recorded in Chapter 3 at Ixworth Thorpe, but higher than the value at Deeping St Nicholas. Other reported densities for Turtle Doves in Britain are 1.4 territories per km^2 on farmland during the period 1968-1972 (Sharrock 1976), 0.6 territories per km^2 in 1988-1991 (Gibbons *et al.* 1993) and 1.6 to 2.1 territories per km^2 (Mason & Macdonald 2000). In woodland the corresponding values were 2.2 and 2.6 territories per km^2 (Sharrock 1976, Gibbons *et al.* 1993). The values reported here are much higher because the CBC plots from which they are derived were specially selected for their higher than average numbers of Turtle Doves, whereas the other values were derived from across the species' breeding range within Britain. However, it is apparent that suitable woodland areas supported a much higher density of Turtle Dove territories compared to farmland. This probably reflected the species' requirement to nest in overgrown bushes, with the woodland plots being used predominately for nesting.

On both the farmland and woodland CBC plots Turtle Doves underwent a significant decrease in breeding density during the period 1965 to 1995. The declines reported here are in line with those reported throughout Britain (Marchant *et al.* 1990, Baillie *et al.* 2001) but this is to be expected as the national population estimate is derived from the CBC plots, albeit a much larger sample.

In very general terms, overall habitat availability, as measured by the proportion of each of the plots occupied by the broad habitat types, did not vary significantly during the period 1965 to 1995. However, at a finer scale it is apparent that a number of changes to habitats on both the farmland and woodland plots have occurred.

Habitat diversity on the farmland plots decreased whereas on the woodland plots it increased. The diversity index that was calculated for the farmland plots took into account a large number of crop and habitat types and the observed decrease in diversity was probably due to the simplification of crop rotations and the removal of non-arable habitats. On the woodland plots the diversity index was calculated for a much more limited range of habitats and the observed increase was probably due to woodland and scrub clearance increasing the amount of other habitats on the plots.

Overall the amount of nesting habitat available for Turtle Doves did not change during the period 1965-1995. However, between the 1960s and 1980s there was an apparent decrease in the hedginess of the farmland plots. This was due to the removal of hedgerows, scrub and woodland. This has occurred throughout much of lowland farmland although the scale of hedgerow removal on the CBC plots seems to be less severe than that which has occurred nationally. The increase in plot hedginess after the mid-1980s probably resulted from the recent planting of farm woodlands and the replanting of hedges, both of which were encouraged by financial incentives.

There was a small, but significant, decrease in the amount of nesting habitat on the woodland CBC plots. This resulted from woodland and scrub clearance for predominately conservation purposes, or occasionally building purposes.

On the farmland plots, which probably also represented the feeding areas used by birds breeding on the woodland plots, there were significant changes in the relative proportion of habitats producing either natural or artificial food. The mean proportion of the plots occupied by natural food-producing habitats decreased. These habitats were replaced by artificial food-producing habitats that increased during the same period. This change in habitat was probably due to intensification of farming systems away from mixed arable and livestock enterprises into purely arable farms (O'Connor & Shrubb 1986).

However, even though there had been a number of changes to habitats on both farmland and woodland plots it was possible to conclude only that the hedginess of the farmland CBC had a detrimental effect on Turtle Dove breeding densities. Similar findings resulted from two earlier studies by Murton & Westwood (1974) and Gillings & Fuller (1999). In both of these studies the authors found significant habitat losses but there was no evidence that they were linked to changes in the densities of breeding birds. A study by Chamberlain & Fuller (2000) found that the abundance of Turtle Doves was negatively related to increases in barley, area of grassland and the number of cattle. Although their analysis was carried out at a finer level than that undertaken here, no association were found between changes in Turtle

Dove numbers and changes in the area of cereals (artificial food) or grassland (natural food). Like Gillings & Fuller (1999), I conclude that the dramatic changes observed in the size of the Turtle Dove UK breeding population are not due solely to habitat loss or gross changes in habitat but are probably caused by overall degradation of habitat quality.

For example, Turtle Doves have specific requirements for tall overgrown thorny bushes for nesting (Chapter 3). However, it was not possible for this study to investigate temporal changes in nesting habitat quality or the effect of different management techniques. It is likely that today's more rigorous hedgerow management, whereby hedges are cut by mechanical flails (Macdonald & Johnson 1995), have reduced the suitability of many hedges as nesting sites by Turtle Doves. So, although in overall terms the apparent availability of hedges as nesting sites on farmland has not decreased, the actual amount of hedges that are suitable may have decreased markedly.

The same may also be true for previously used feeding areas, such as grassland. These may not have changed at the landscape level, occurring in the same amount as before, but may have changed at a finer scale. For example, grasslands may occupy the same area of the countryside today as during the 1960s, but changes in management including the type of grass grown, cutting regimes and the amount of fertilisers and herbicides applied (O'Connor & Shrubb 1986) may have rendered them unsuitable as feeding areas for Turtle Doves. Unfortunately the extensive data available from CBC plots is not at a fine enough level of detail to investigate this.

In terms of habitat use the results from this Chapter support those of Chapter 3. Turtle doves appear to establish their territories in areas that contain more non-cropped habitats (particularly woodland habitats) than cropped habitats, relative to availability. The results of the two Chapters differ slightly in that habitats categorised as "Other" appeared to be used more in Chapter 3 than on the CBC plots. However, this probably a consequence of the level of habitat recording, which was carried out at a finer level for the work in Chapter 3.

CHAPTER 9

BREEDING SUCCESS OF TURTLE DOVES BETWEEN 1940 AND 2000: AN ANALYSIS OF NEST RECORD CARDS.

9.1 Introduction

Chapter 3 provided information on the breeding success of Turtle Doves, based on data collected during the 1998-2000 breeding seasons. In order to investigate temporal changes in breeding success of individual nesting attempts on a broader national scale, long-term dataset held by the BTO under the Nest Record Card Scheme (NRS) was analysed.

9.2 Methods

Having started in 1940 and continuing today, the NRS is the largest dataset of information on avian breeding biology in the UK. It comprises individual cards that contain a range of information on bird nests (one card per nest) and their outcome. Full details of the NRS are provided by Crick & Baillie (1996) and only a summary is given here.

Contributors to the BTO NRS are volunteer nest finders who complete a standardised card to record information on each nest that they find. The information that they record can be categorised into three groups. They collect information on the nest, the habitat surrounding the nest and nest outcome, which may result from one or numerous visits. In total, approximately 2000 Turtle Dove nest record cards have been submitted to the BTO and the information they contain has been partially computerised. However, not all the cards contain all the potential information and many are based on only one visit to the nest.

9.2.1 Statistical analysis

Information on nesting site, type of bush used, nest outcome and nest height was extracted from the Turtle Dove nest record cards from 1941 to 2000. The cards were grouped into five broad categories based on the descriptions of general nesting habitats. These were hedgerow, plantation, scrub, woodland and isolated bushes (which included bushes in gardens). The type of tree used for nesting was categorised into a number of broad types based on the main trees used in Chapter 3. The categories were Elder, fruit trees, thorn (Hawthorn and Blackthorn), broad-leaved (excluding Elder, thorn and fruit trees) and coniferous. For cards where nest fate was known the data were categorised into successful, predated and abandoned. The information extracted from the cards was grouped into five-year periods to increase sample sizes in the early and late years. Chi-square tests were used to compare the number of cards in each of the habitat and outcome categories, based on counts of cards in each group. Kruskal-Wallis test compared median nest height between the five-year periods. Before the mid-1980s nest height was usually given in feet and this was converted to metres before analysis. The standard error of the median was calculated as 1.25*(S.E. mean) (Snedecor & Cochran 1980).

First-egg date was calculated for all nest record cards where there were sufficient visits to enable an accurate estimate to be made. First-egg date estimates took into account laying period, the timing of hatching and fledging and were based on an incubation period of 14 days and a nestling period of 15 days. Other authors (Siriwardena *et al.* 2000) have used 20 days as the length of the incubation period, but information from Chapter 3 implies that 14 and 15 days are more accurate estimates. For some cards it was possible to calculate only minimum and maximum first-egg dates, in this case a mean of the two values was used. Days were assigned a numerical value where 1 March = 60. Differences in median first-egg dates between five-year periods were tested with a Kruskal-Wallis test. Standard errors of the median were calculated as 1.25*(S.E. mean).

The Mayfield method (see Mayfield 1961, 1975, Hensler & Nichols 1981, Hensler 1985) was used to calculate the daily survival rate (DSR) for Turtle Dove nests during the incubation and nestling periods separately, and to provide an estimate of overall breeding success. Only nests visited more than once were included in the analysis. The analysis was based on nest outcome and partial losses were not considered. If the precise day of failure or hatching was not known the mid-point between the two visits either side of the event was used. To overcome the problem of small sample sizes, particularly in the early and late years, data were grouped into five-year periods and corresponding daily and overall nest survival rates estimated. Linear trends over time in overall nest survival rates during the incubation and nestling stages were tested using regression against the mid-point of each time period, weighting by 1/V where V is the variance of each estimated rate.

An extension to the Mayfield method using logistic regression (Aebischer 1999) was used to investigate variations in nest survival during the incubation and nestling periods in relation to year (both as a categorical and a continuous variable), habitat and their interaction. Each card was assigned to one of five broad habitat groups (woodland, farmland, grassland, scrub and other) based on the habitat information supplied on the card. If no habitat information was available the card was not included in the analysis.

9.3 Results

9.3.1 Nest site

The nest sites used by Turtle Doves and recorded on nest record cards are summarised in Table 9.1. Although there was a significant difference in the number of nests recorded in each of the habitat categories in each of the five-year periods between 1940 and 2000 ($\chi^2_{44} = 254$, $P < 0.001$), no obvious trend over time was apparent. The nesting site recorded most often was scrub followed by hedges and then woodland, with coniferous plantations being recorded least often. The type of trees used for nesting are summarised in Table 9.2. Again, although the number of nests in each of the tree type categories varied significantly between the five-year periods ($\chi^2_{40} = 97.46, P < 0.001$), there was no discernible trend over time. Thorny trees (principally Hawthorn and Blackthorn) were the type of tree most often recorded.

Table 9.1 Habitats used by Turtle Doves (%) for nesting during the period 1941 to 2000 and recorded on nest record cards.

Five-year period	Number of cards	Isolated bush	Hedge	Plantation	Scrub	Woodland
1941-45	46	6.5	60.8	0.0	32.6	0.0
1946-50	17	20.0	33.3	6.7	26.7	13.3
1951-55	99	11.1	7.1	7.1	61.6	13.2
1956-60	86	10.5	13.9	4.6	52.3	18.6
1961-65	245	6.1	10.1	10.9	50.0	22.9
1966-70	331	5.4	19.1	8.2	41.9	25.4
1971-75	270	4.4	11.8	7.4	50.0	26.3
1976-80	291	6.2	17.5	5.8	47.7	22.7
1981-85	146	2.7	19.2	5.5	50.7	21.9
1986-90	129	13.2	19.4	3.1	51.2	13.2
1991-95	61	10.6	22.7	15.2	37.8	13.6
1996-00	97	29.9	25.7	0.0	39.2	5.2
Overall	1818	7.8	17.3	6.8	47.5	20.5

Table 9.2 Type of tree used by nesting Turtle Doves (%) during the period 1941 to 2000 and recorded on nest record cards.

Five-year period	Number of cards	Broadleaved	Coniferous	Elder	Fruit	Thorn
1946-50	14	21.4	7.2	7.2	0.0	64.3
1951-55	94	23.4	8.5	14.9	1.1	52.2
1956-60	73	27.4	6.8	17.8	2.7	45.2
1961-65	237	19.8	6.7	22.4	8.1	43.1
1966-70	319	18.5	6.9	18.2	2.8	53.6
1971-75	266	18.4	7.2	18.1	2.6	53.7
1976-80	288	23.6	7.9	7.9	1.1	59.4
1981-85	153	21.6	11.1	14.4	1.3	51.6
1986-90	128	15.6	5.5	14.1	1.6	63.3
1991-95	60	21.7	16.7	6.7	1.7	53.3
1996-00	96	14.6	3.2	10.4	0.0	71.8
Overall	1728	20.2	7.6	15.3	2.6	54.4

9.3.2 Nest height

The median nest height did not vary significantly between the five-year periods from 1940 to 2000 (Kruskal-Wallis $K_{11} = 19.32$, $P = 0.056$; Figure 9.1). There was no significant linear trend during the same time period ($r_{10} = 0.286$, $P = 0.368$). Overall median nest height during this period was 2.14 ± 0.31 m (n = 1854, range = 0.2–12.22 m).

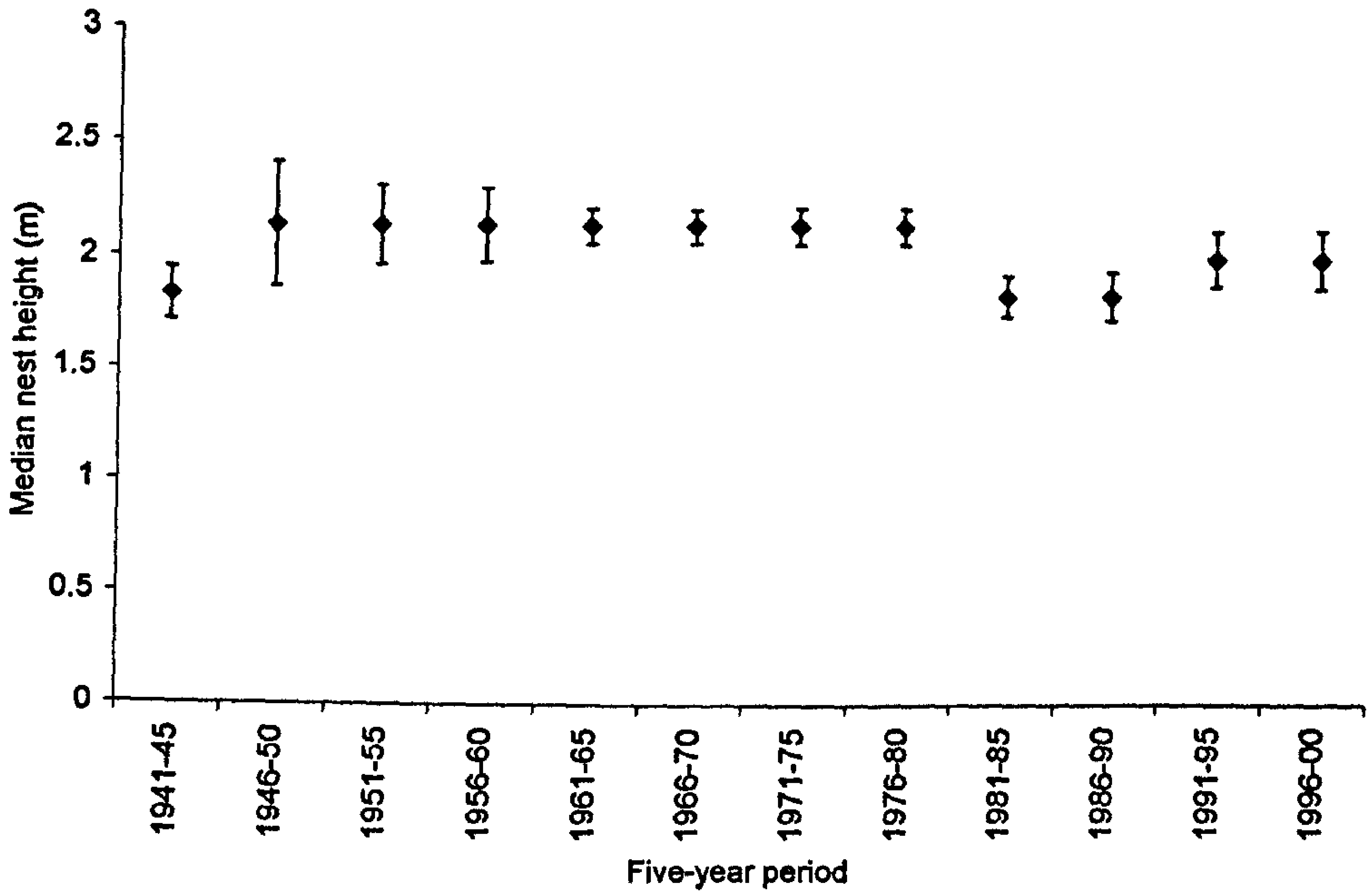


Figure 9.1 Median nest height for Turtle Dove nests recorded on BTO nest record cards during the period 1941 to 2000. Error bars represent 1 standard error.

9.3.3 First-egg date

Median first-egg date during the period 1950-2000 ranged from 28 April to 26 May (Figure 9.2). There was a significant difference in median first-egg date between the five-year periods (Kruskal-Wallis K_9 = 22.96, P = 0.003), but there was no significant linear trend in first-egg date (r_8 = 0.214, P = 0.551)

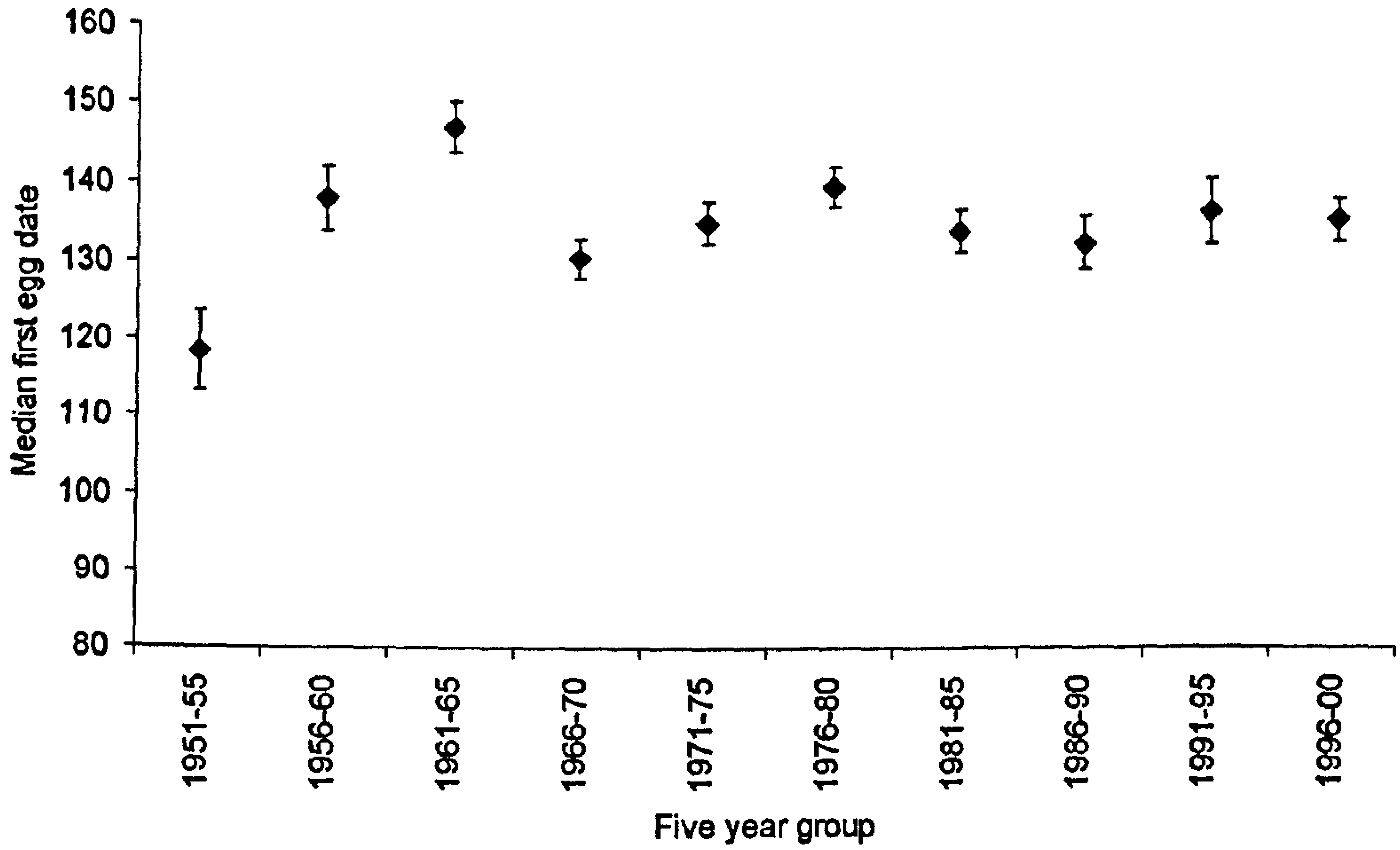


Figure 9.2 Median first-egg date(1st March = 60) for Turtle Dove nests recorded on BTO nest record cards during the period 1951 to 2000. Error bars represent 1 standard error.

9.3.4 Nest fate

Fates nests recorded on NRCs during the period 1941-2000 are summarised in Table 9.3. There was no significant difference in nest fate in the five-year periods between 1940 and 2000 ($\chi^2_{22} = 32.34, P = 0.072$). Overall 41.3 ± 1.4% of nests successfully produced young, 44.9 ± 1.5% were predated, with the remainder being abandoned (Table 9.3).

Table 9.3 Nest outcome (%) for Turtle Dove nests during the period 1941 to 2000 And recorded on nest record cards

Five-year period	Number of cards	Abandoned	Predated	Successful
1941-45	28	3.6	50.0	46.4
1946-50	11	9.1	45.5	45.5
1951-55	64	12.5	48.4	39.1
1956-60	49	18.4	40.8	40.8
1961-65	144	22.2	37.5	40.3
1966-70	209	13.8	44.1	42.1
1971-75	191	16.3	45.5	38.2
1976-80	215	13.5	53.5	33.1
1981-85	130	9.3	42.3	48.5
1986-90	101	11.8	43.6	44.5
1991-95	49	8.2	48.9	42.8
1996-00	74	9.5	36.5	54.1
Overall	1265	13.8	44.9	41.3

9.3.5 Breeding success

Incubation

The daily survival rate of individual Turtle Dove nests during the incubation period over the five-year periods between 1950 to 2000 ranged from 0.948 to 0.972, and averaged 0.961 ± 0.002. This meant that overall nest survival during the 14-day incubation period ranged from 0.479 to 0.674 (average 0.577 ± 0.019); there was no evidence of a linear trend over time (r_8 = -0.368, P = 0.295; Figure 9.3a).

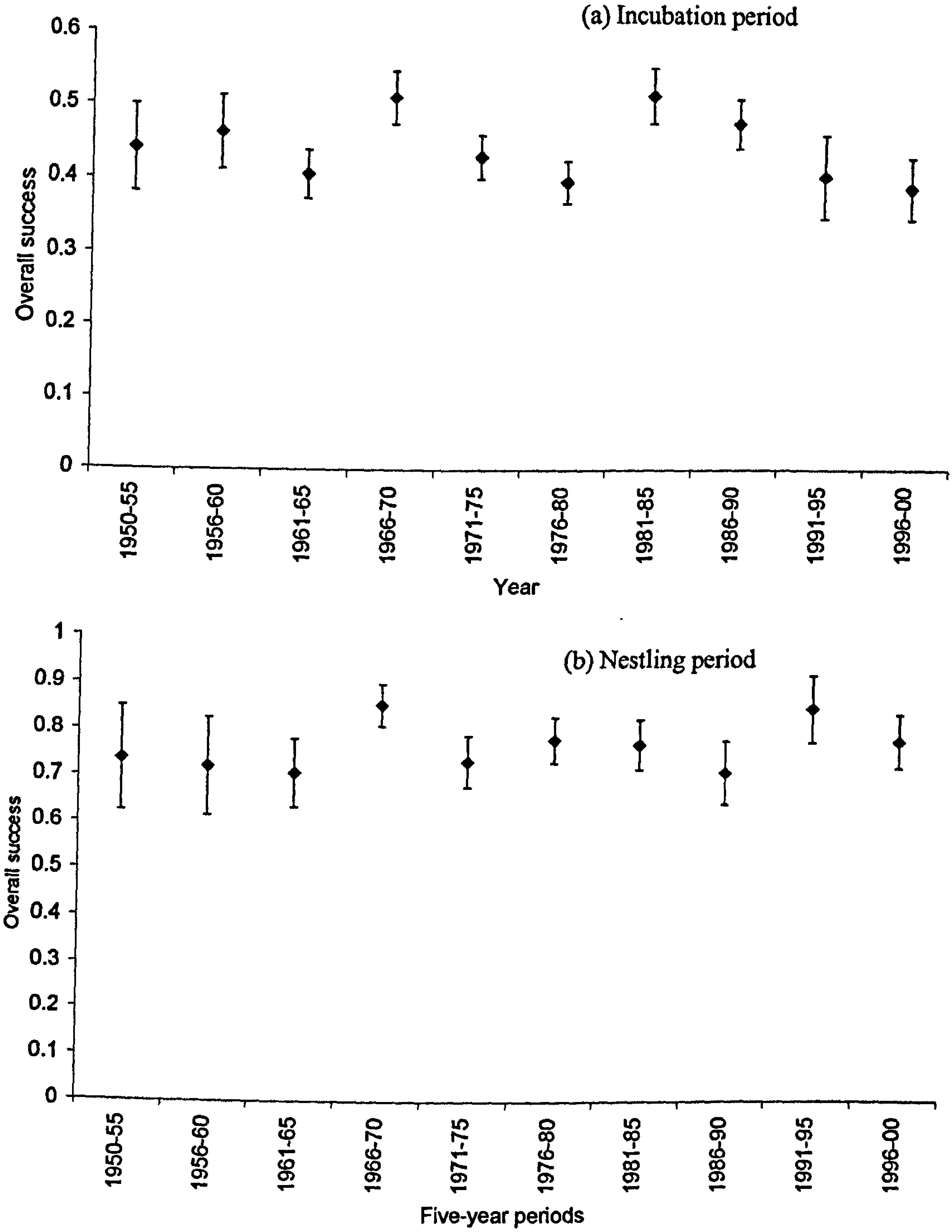


Figure 9.3 Nest survival rate of Turtle Dove nests recorded on BTO nest record cards during the a) incubation stage and b) nestling stage in each of the five-year periods between 1951 to 2000. Error bars represent 1 standard error.

The logistic regression analysis of breeding success during the incubation period included the terms year and habitat in the model. There was a significant interaction between year and habitat when year was entered into the model as a categorical variable ($\chi^2_{153} = 196.8, P = 0.009$). When nests were grouped into five-year periods the interaction between habitat and time period was also significant ($\chi^2_{37} = 57.7, P = 0.016$). However, when time was entered into the model as a continuous variable the interaction between time and habitat was not significant ($\chi^2_4 = 4.9$, $P = 0.297$). After dropping the non-significant interaction term from the model, breeding success did not vary with habitat ($\chi^2_4 = 2.60, P = 0.626$) or time ($\chi^2_1 = 2.20, P = 0.138$).

Nestling period

The daily survival rate of Turtle Dove nests during the five-year periods between 1950 to 2000 ranged from 0.977 to 0.988 and averaged 0.982 ± 0.002. This corresponded to overall nest survival during the 15-day nestling period ranging from 0.707 to 0.853 (average 0.771 ± 0.019). There was no evidence of a linear trend over time in overall nest survival during the nestling period ($r_8 = 0.352, P = 0.319$; Figure 9.3b).

When year was entered as a categorical variable into the logistic regression model there was a significant interaction between year and habitat ($\chi^2_{143} = 190.4$, $P = 0.004$). When nests were grouped into five-year periods the interaction between habitat and time period was also significant ($\chi^2_{39} = 52.0, P = 0.07$). However, when time was entered into the model as a continuous variable the interaction between time and habitat was not significant ($\chi^2_4 = 7.30$, $P = 0.121$). After dropping the non-significant interaction term from the model, breeding success did not vary with habitat ($\chi^2_4 = 4.30$, $P = 0.367$) or year ($\chi^2_1 = 0.10$, $P = 0.752$).

Overall nesting period

Overall breeding success during the entire nesting period ranged from 0.389 to 0.514 (average 0.445±0.135). There was no evidence of a linear trend over time in overall breeding success ($r_8 = 0.214$, $P = 0.552$; Figure 9.4).

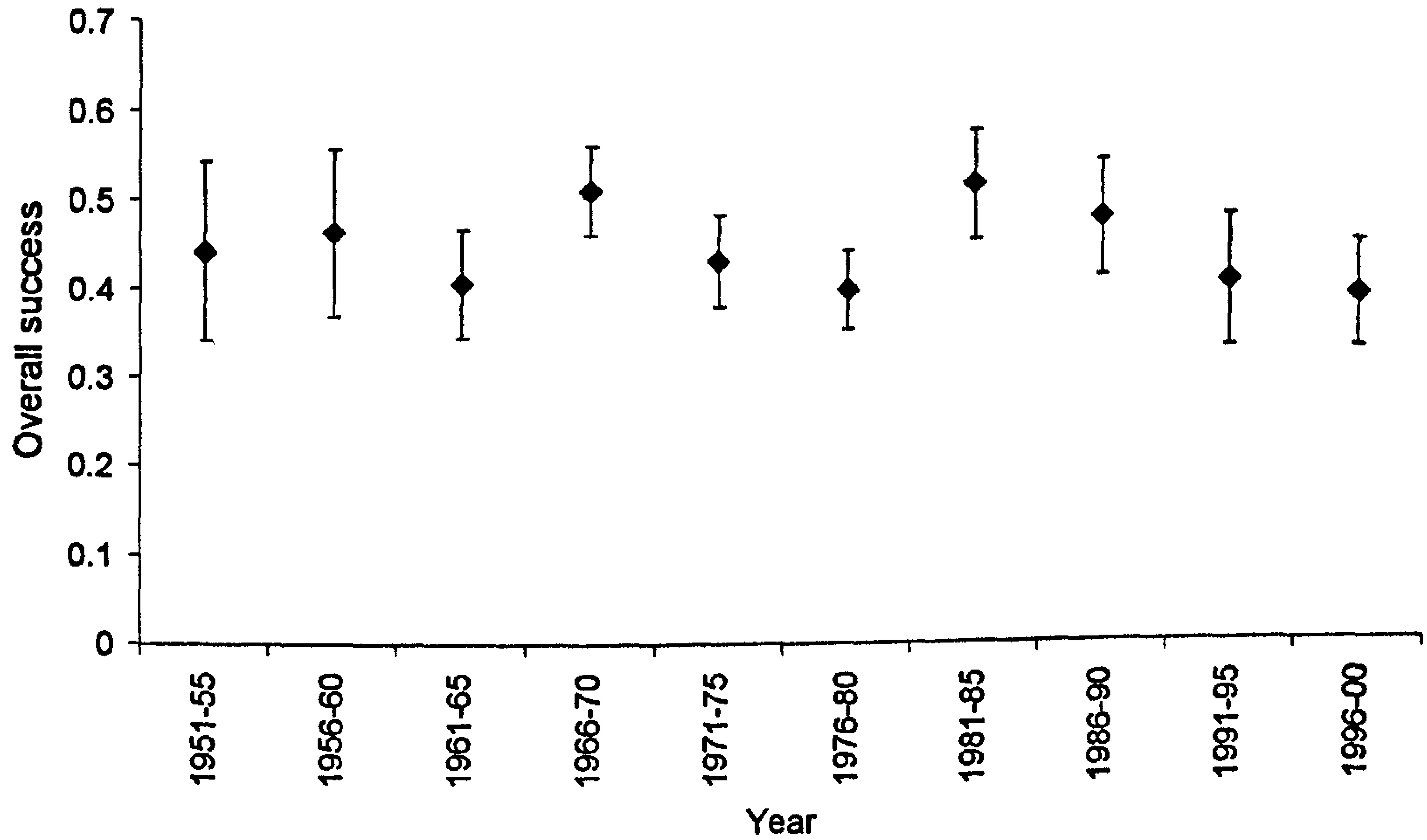


Figure 9.4 Overall nest survival rate of Turtle Dove nests recorded on BTO nest record cards in each of the five-year periods between 1951 to 2000. Error bars represent 1 standard error.

9.4 Discussion

The results presented here show that there have not been any detectable trends over time in any aspect of Turtle Dove breeding ecology, based on individual nesting attempts during the period 1940 to 2000.

There were some differences between individual time periods, but overall the habitats and types of trees and bushes used for nesting have not changed. Turtle doves nest predominately in scrub or hedge habitats and situate their nests in either thorny or broad-leaved trees or bushes. Nest height has also not changed during this 60-year period.

The outcome and success of individual nests did not change during the period 1940 to 2000 or within different habitat types, for either the incubation or the nestling stage. It is therefore possible to conclude that the population decline experienced by Turtle Doves breeding in Britain is not due to the lowered breeding performance of individual attempts. If productivity is the cause, then the decline must be a consequence of reduced breeding performance for each pair of Turtle Doves throughout the breeding season.

A similar analysis to that undertaken here was performed by Siriwardena *et al.* (2000) but it was restricted to Turtle Dove NRCs that were classified as farmland. They also concluded that the Turtle Dove population declines were not associated with poor breeding performance per attempt and postulated that post-fledgling survival and/or a reduction in the number of attempts per year may have been of more importance.

CHAPTER 10

THE MIGRATION OF BRITISH TURTLE DOVES

10.1 Introduction

The Turtle Dove is the only UK member of the pigeon family (Columbidae) that undertakes long-distance migration spanning over 4000 km. The species' annual migration combined with its exclusively granivorous diet sets it apart from all other declining farmland bird species in the UK. This migratory behaviour has consequences for the breeding ecology of the species, particularly the timing of breeding. First, birds can start breeding only once they have arrived on the breeding grounds. Second, migration is known to place birds under considerable physiological stress, which has the potential to affect body condition and hence breeding performance.

A number of authors have studied or reported the Turtle Dove's migratory behaviour. These studies have considered birds specifically from Britain and more generally along the entire migration route from Britain to sub-Saharan Africa. The two main studies are those of Murton (1968) and Aebischer (*in press*) which used recoveries of ringed Turtle Doves to identify the timing of migration to and from Britain and the route taken. A study undertaken by Riddiford (1991) used observational data collected between 1953 and 1977 at Dungeness Bird Observatory on the South coast of Britain to describe the phenology and annual fluctuations in Turtle Dove migration. Studies by Lofts *et al.* (1967) and Guyomarc'h (1998) considered the physiology and behaviour of Turtle Doves during the post-breeding pre-migratory period. Other authors provide information, based mainly on observational data, on the migration route taken by Turtle Doves through Europe, the numbers involved and the strategies used (e.g. Marchant 1969, Ash 1977, Bourne & Beaman 1980, Mountfort 1981, Devort *et al.* 1988, Jarry 1995). The final aspect of Turtle Dove migration to have been considered is the timing of arrival/departure and distribution across the species' wintering areas in Africa (Curry & Sayer 1979 and Morel 1985, 1987, 1988). A detailed description of British Turtle Dove migration is provided by Aebischer (*in press*) and only a summary is provided here.

After breeding, Turtle Doves start to leave Britain in August, with the last birds leaving in October. The migration route takes them through western France, central and western Iberia along the Atlantic coast of Morocco, through Mali and Senegambia into Western Africa. The over-wintering area extends from Senegambia and southern Mali in the North to the Gulf of Guinea in the South, the Atlantic coast in the East and Cameroon and Nigeria in the West. The main wave of migration takes place from mid-August, when the birds leave Britain, to late October when most birds arrive in Western Africa. Migration is thought to be mainly nocturnal, but there is a diurnal component at times. Turtle doves tend to migrate in flocks of between 5-30 individuals, but flocks of over 100 birds are regularly reported. Large congregations of up to 1000 can occur in food-rich areas, such as ripe sunflowers. Spring migration starts during February-March when huge flocks of many hundreds of thousands birds can occur in Mali and Senegambia. Turtle doves arrive in Britain from mid-April through to June, with the main influx occurring during May.

The aim of this study was to establish the migratory pattern of Turtle Doves to and from the UK. Also this study aims to establish whether changes in the timing of breeding (Chapter 3) are linked to temporal changes in the species' migratory behaviour.

10.2 Methods

10.2.1 Data extraction

Information on Turtle Dove migration was obtained from all bird observatories within the breeding range of the Turtle Dove in the UK. These observatories were Dungeness (Kent), Gibraltar Point (Lincolnshire), Holme (Norfolk), Landguard (Suffolk), Portland (Dorset) and Sandwich Bay (Kent) (Figure 10.1). Although Turtle Doves were regularly recorded at the other observatories, the numbers recorded were very small and it was thought that these birds probably represented those on passage through the UK heading towards the continent.

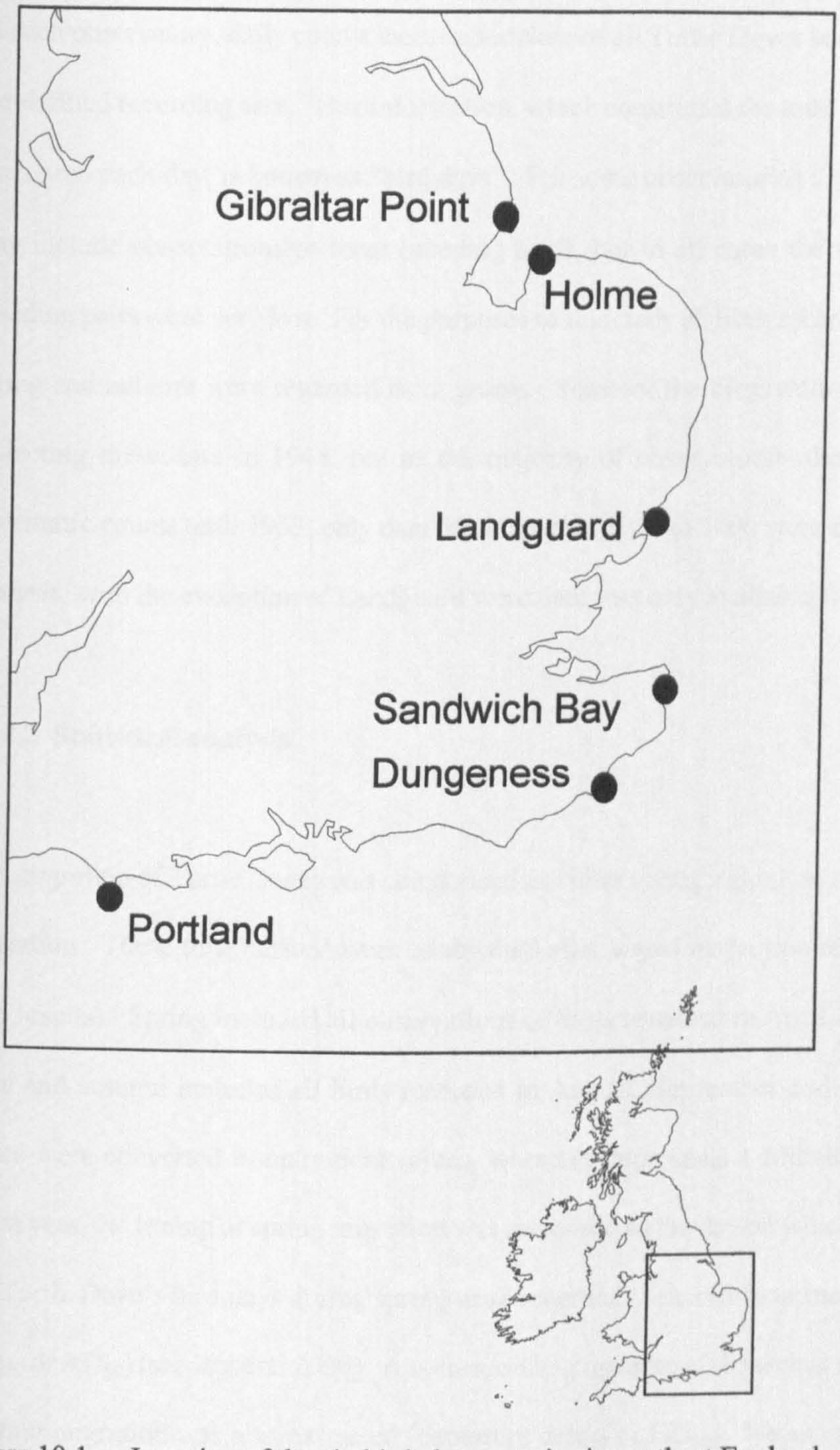


Figure 10.1 Location of the six bird observatories in southest England.

At each observatory, daily counts were undertaken of all Turtle Doves seen within a pre-defined recording area. This information, which constitutes the total number of birds seen each day, is known as "bird days". For some observatories the bird days may include observations of local breeding birds, but in all cases the number of breeding pairs were very low. For the purposes of this study all birds recorded during spring and autumn were regarded as migrants. Some of the observatories started collecting these data in 1948, but as the majority of observatories did not start systematic counts until 1963, only data for the period 1963 to 2000 were used in the analysis, with the exception of Landguard were data was only available from 1983.

10.2.2 Statistical analysis

The migration of Turtle Doves was categorised as either spring migration or autumn migration. These time periods were established after visual inspection of the data (see results). Spring included all observations of birds recorded in April, May and June and autumn included all birds recorded in August, September and October. Dates were converted to numerical values, where 60 represents 1 March. In any given year, the timing of spring migration was measured as the day on which 50% of the Turtle Dove's bird-days during spring were recorded (henceforth termed arrival $date_{50}$ or AD_{50}) (see Roberts 2000). A corresponding measure of the annual timing of autumn migration was also extracted (departure $date_{50}$ or DD_{50}). Mean values for AD_{50} and DD_{50} were calculated for each year, averaged across the six observatories and used for presentation.

In order to derive a series of mean annual values taking into account the absence of the data before 1983 from Landguard, a two-way analysis of variance with observatory and year as factors on total bird days, AD_{50} and DD_{50} was used. The year coefficients were used as mean annual indices.

10.3 Results

10.3.1 Turtle dove migration through the Observatories

The average number of turtle doves recorded at observatories each year increased approximately threefold during the 1960s and 1970s, then decreased by nearly the same amount (Figure 10.2). In the 1970s and 1990s the number of bird days recorded was between approximately 200 and 300, with maximum counts of about 550 in 1967 and 600 in 1972. During the peak period, the number of bird days recorded increased to about 750 on average, with two maxima of about 1000 in 1977 and about 1150 in 1979.

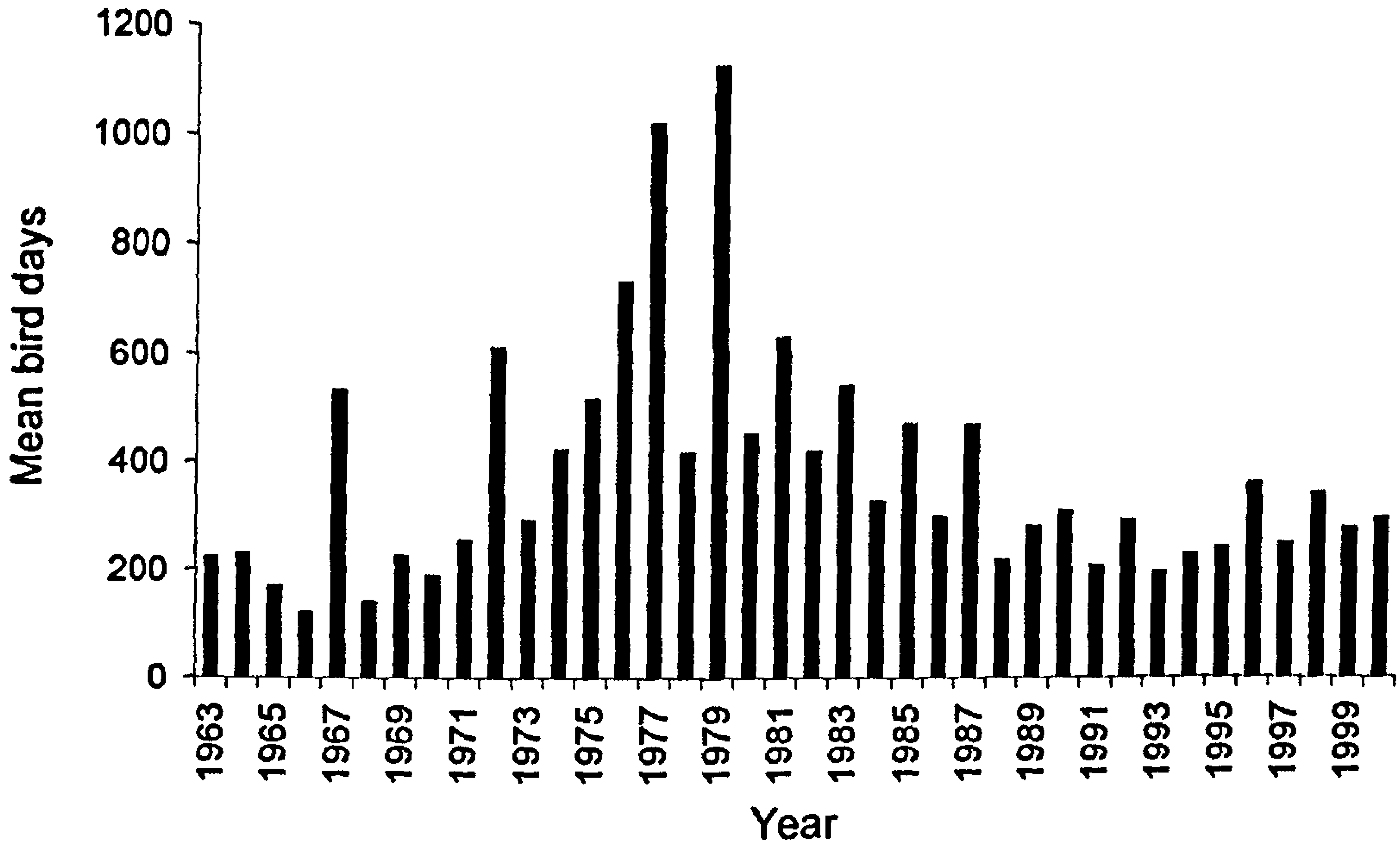


Figure 10.2 Mean number of Turtle Dove bird days recorded between 1963 and 2000 at the six bird observatories in southest England (see text).

10.3.2 Timing of migration

Spring migration of Turtle Doves into Britain started in early April, with the peak of migration occurring between mid-May and mid-June (Figure 10.3). By the end of June the numbers of birds recorded each day levelled off and probably represented local breeding birds. Autumn migration was not as obvious as spring migration. The number of birds recorded increased slightly from early August through to late September. A few birds were recorded throughout October.

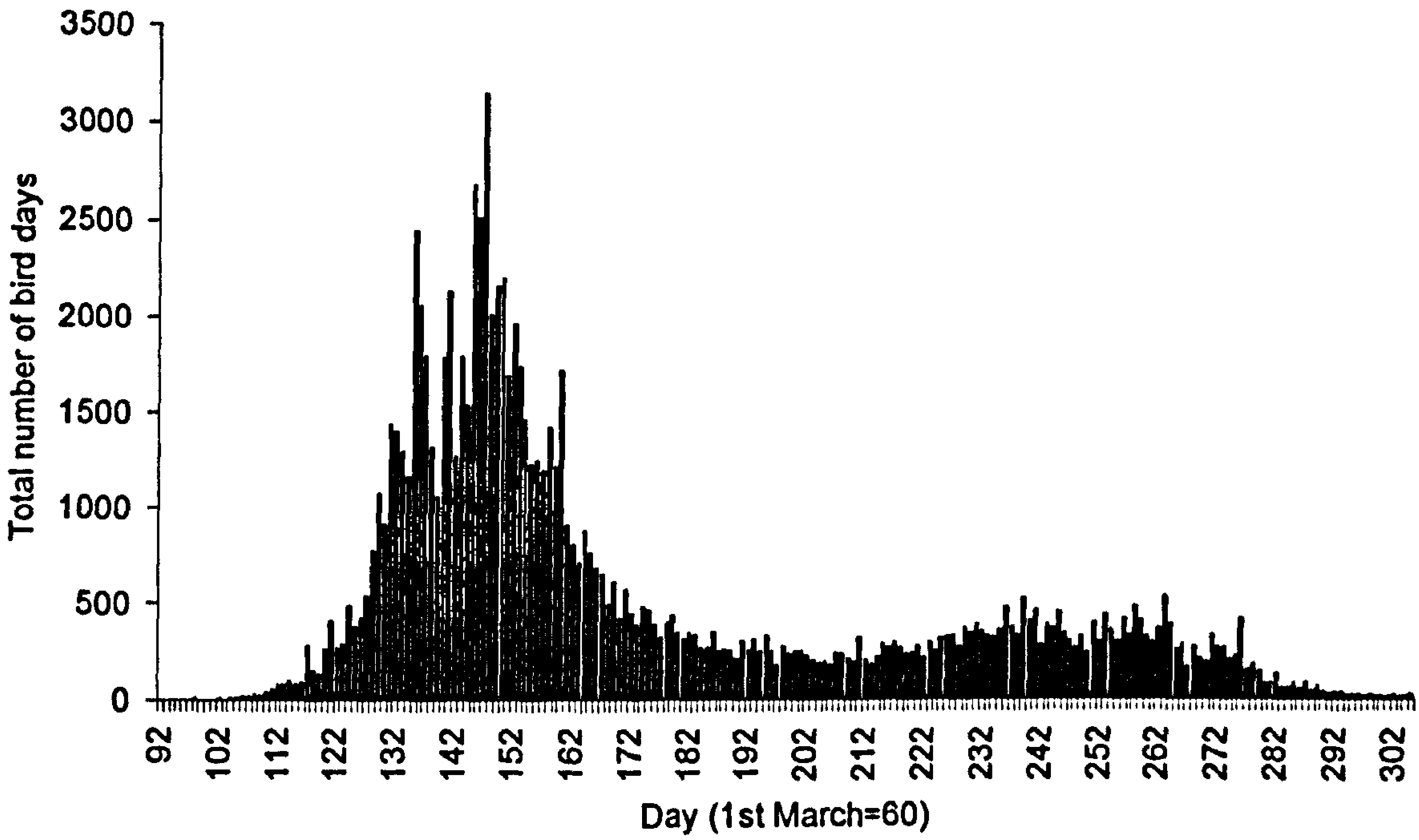


Figure 10.3 Total number of Turtle Doves recorded each day between 1963 and 2000 at the six bird observatories in southest England (see text).

In general terms, spring migration of turtle doves into Britain started in mid-April, with the peak of migration occurring between late-April and early-June (Figure 10.4). By the end of June the numbers of birds recorded each day leveled off and probably represents local breeding birds. Autumn migration was not as obvious as spring migration, except at Portland. The number of birds recorded increased from early August through to late September. A few birds are recorded throughout October.

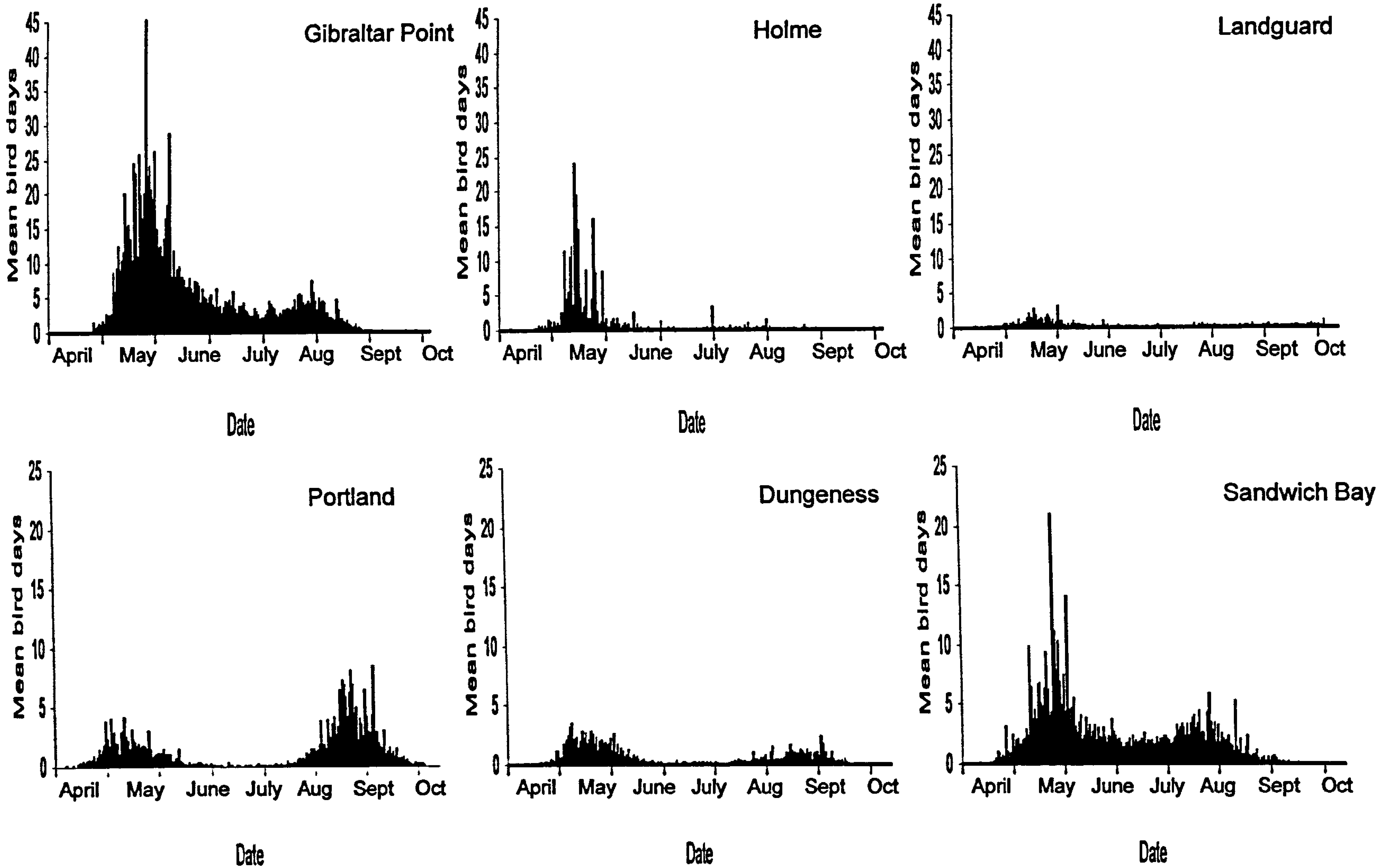


Figure 10.4 Mean number of turtle doves recorded each day between 1960 and 2000 at the six bird observatories in southeast England.

10.3.3 Turtle dove arrival and departure dates

There was no significant interaction between observatory and year (as a covariate) when considering AD_{50} ($F_{5,196}$=0.62, $P > 0.05$). After removing the interaction it was found that AD_{50} varied significantly with observatory ($F_{5,201}$=13.45, $P < 0.001$) but not with year ($F_{1,201}$=3.25, $P > 0.05$; Figure 10.5). There was not a significant interaction between observatory and year when analysing DD_{50} ($F_{5,196}$=1.02, P = 0.411). DD50 varied significantly with observatory ($F_{5,201}$=41.72, $P < 0.001$) and year ($F_{1,201}$=11.65, $P = 0.001$; Figure 10.6). Over the 38-year period between 1963 and 2000 the annual rate of change in DD_{50} was –0.22 ± 0.07 days. Median departure date is approximately 8.5 days earlier today compared to 1963.). The difference between DD_{50} and AD_{50} (DD_{50}-AD_{50}), representing the length of the breeding season, had a significant negative trend over the 38-year period (r_{36} = -0.569, $P < 0.001$). The annual rate of change in the length of the breeding season was –0.33 ± 0.08, representing an average shortening of the breeding season between 1962 and 2000 of 12.2 days.

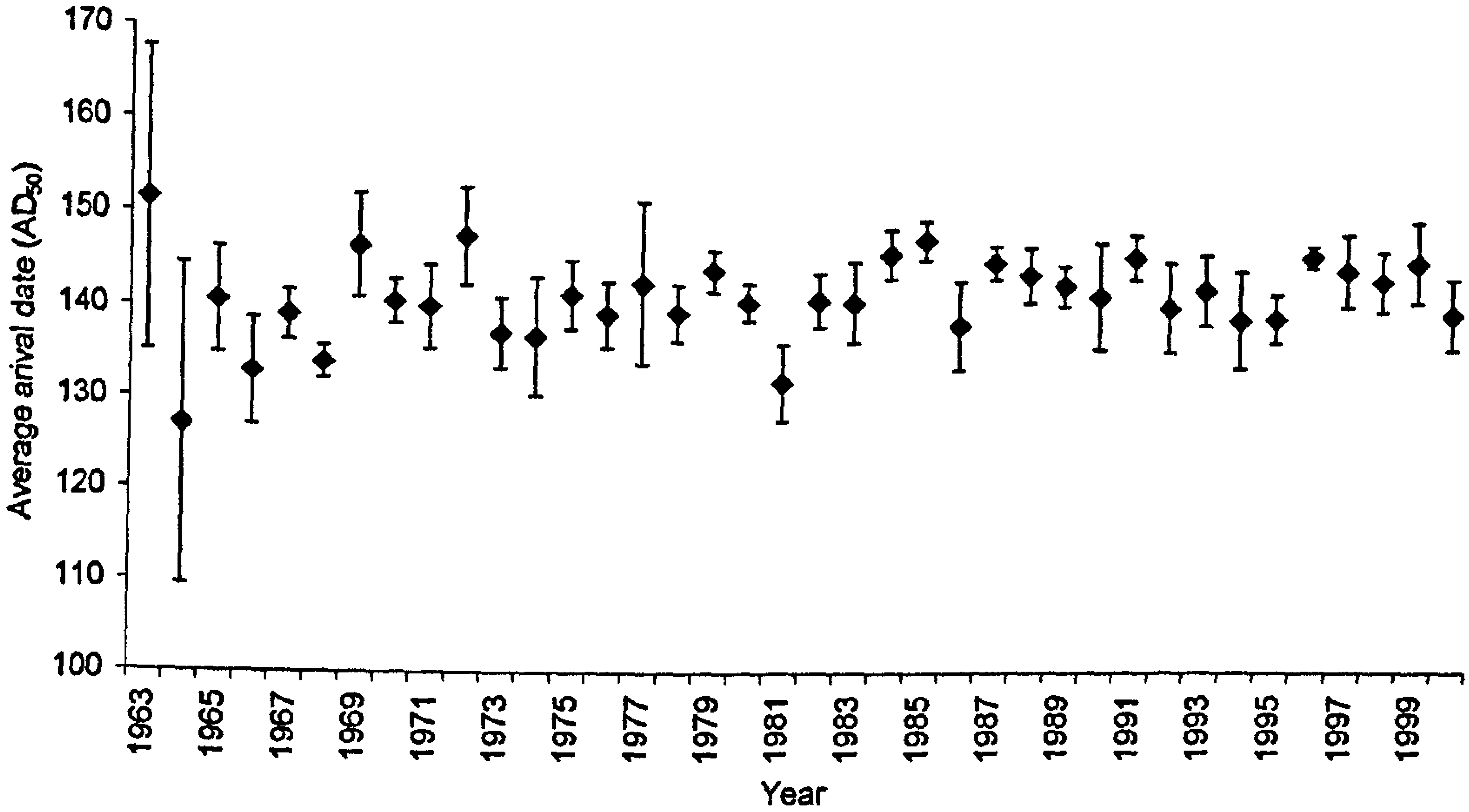


Figure 10.5 Mean spring arrival date (AD_{50} - see text) between 1963 and 2000 at the six south-eastern bird observatories. Error bars represent 1 standard error.

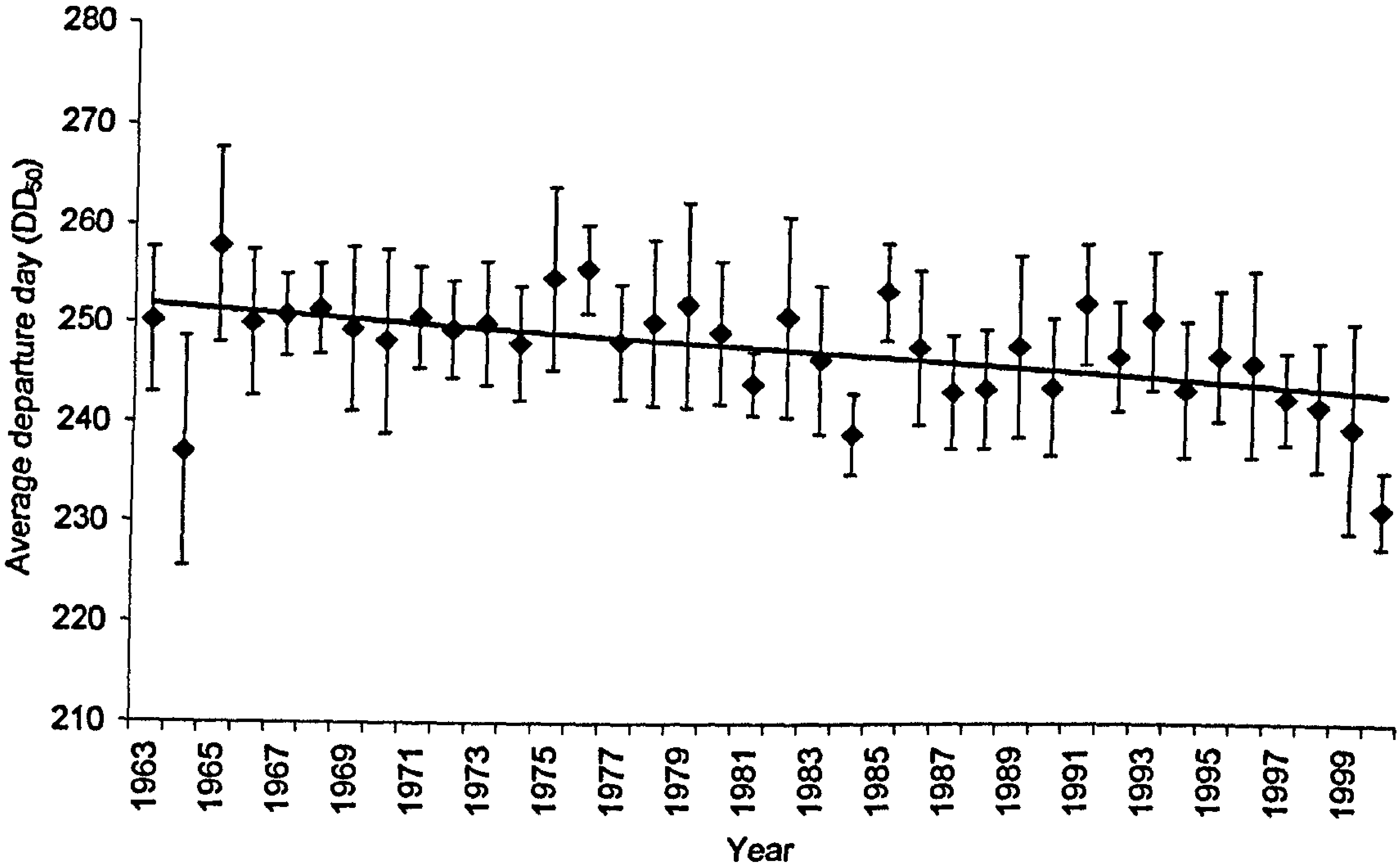


Figure 10.6 Mean autumn departure date (DD_{50} - see text) between 1963 and 2000 at the six bird observatories in southeast England. The regression equation of the trend line is $y = 707.68 + -0.232x$. Error bars represent 1 standard error.

10.4 Discussion

The trend in the number of Turtle Doves recorded on migration through the south coast bird observatories between 1960 and 2000 followed a similar pattern to the trend of abundance as recorded by the overall CBC scheme (Marchant *et al.* 1990, Baillie *et al.* 2001). However, as both datasets provided a measure of the number of Turtle Doves breeding in the UK, this was not surprising.

Turtle doves were much more obvious during spring migration than on autumn migration. It is likely that as the species is mainly a nocturnal migrant (Devort *et al.* 1998, Jarry 1995), many departing birds are not observed. Arriving birds, which make land-fall along the coast after arriving exhausted from a sea crossing, are more likely to be seen by day as they take time to feed before moving inland.

In recent years, Turtle Doves undertook their autumn migration significantly earlier than in the 1960s. Given that the timing of spring migration did not alter significantly, Turtle Doves now have a shorter breeding season. One of the main findings of Chapter 3 was that Turtle Doves undertook fewer nesting attempts and consequently had lower breeding productivity than in the 1960s. The results presented here support this and show that the British breeding population of Turtle Doves as a whole are now completing breeding and starting migration earlier than in the past.

CHAPTER 11

TURTLE DOVE BODY CONDITION

11.1 Introduction

One of the main findings of Chapter 3 was that the number of nesting attempts undertaken by Turtle Doves in the late 1990s was almost half the number undertaken during the early 1960s. One hypothesis is that reduced food availability has reduced adult body condition making it more difficult for them to undertake repeated nesting attempts. This is investigated using Turtle Dove biometric data collected over the last 40 years.

11.2 Methods

11.2.1 Data collection

Turtle dove biometric data were collated from within the British ringing scheme by approaching ringers directly via an appeal for data in the Ringers' Bulletin; extracting data from the Bird Observatory records; and by requesting data from the BTO's computer database. Wing length measurements (mm) and body weight (g) were available for 480 Turtle Doves weighed and measured between 1960 and 2000. Data collected during this study were also included.

11.2.2 Statistical analysis

Wing length was used as a measure of Turtle Dove body size, and body weight was used as a measure of body condition. To overcome the problem of small sample sizes in some years, data were averaged within 5-year periods. The temporal trends in wing length and body weight were investigated by linear regression of the 5-year means against the mid-point of the corresponding time periods. The data were divided according to season of capture as follows: spring (all captures before 1st July), summer (1st July to 31st July) and autumn (all captures after 1st August).

11.3 Results

11.3.1 Wing length

The overall mean wing length for Turtle Doves during the period 1960-2000 (n=470) was 177.2 ± 0.3 mm (range 160–192 mm). The mean wing length of adults (n=381) was 178.7 ± 0.3 mm (range 160-192 mm) which was significantly larger than the juvenile mean wing length of (n=89) 170.8 ± 0.9 mm (range 132-185 mm) (t_{468}=10.99, P < 0.001). The wing length of males (mean=181.2 ± 0.4 mm, range 170–192 mm, n=122) was significantly larger than female wing length (mean=177.1 ± 0.38 range 170–190 mm, n=130) (t_{250}=7.26, P < 0.001). There was a significant interaction between age and five year period when investigating their effect on wing length (2-Way ANOVA, $F_{8,451}$=3.47, P = 0.001). However, when time (year) was entered as a linear variable, after removing the non-significant interaction ($F_{1,466}$=0.221, P = 0.639), wing length did not change significantly with age ($F_{1,466}$=0.28, P = 0.598), but did change significantly with year ($F_{1,466}$=11.30, P = 0.001). There was a significant increase in mean adult wing length during spring over the period 1960-2000, but not during summer and autumn(Table 11.1; Figures 11.1 to 11.3).

Table 11.1 The results from analysis of Turtle Dove mean wing length (adult only) and mean body weight during five-year periods between 1960 to 2000.

	Wing	**Weight**
Spring	r_6=0.726, P = 0.042	r_6=0.309, P = 0.499
Summer	r_4=0.496, P = 0.396	r_4=0.265, P = 0.613
Autumn	r_6=0.362, P = 0.339	r_5=0.371, P = 0.413

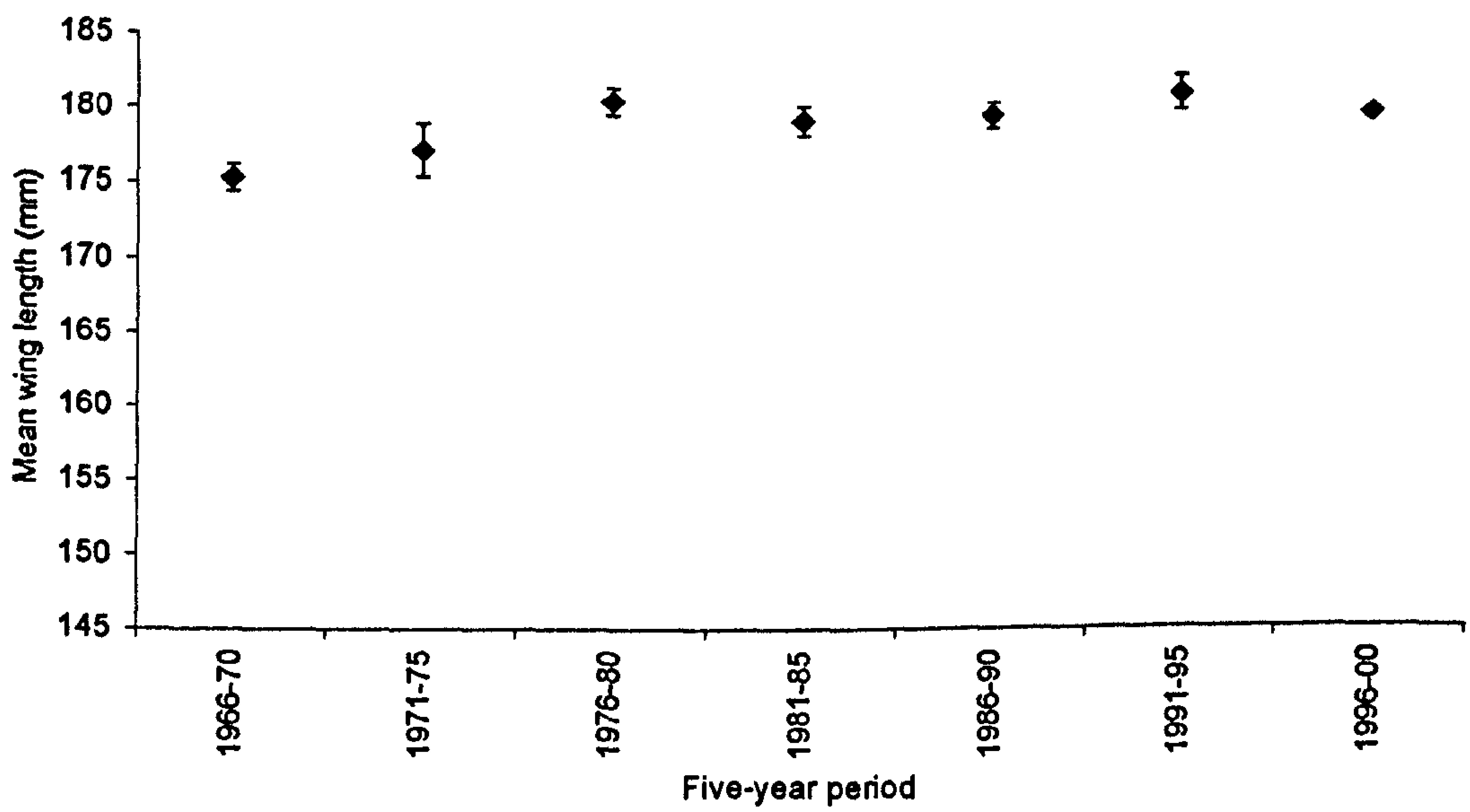


Figure 11.1 Mean adult Turtle Dove wing length in spring for each five-year period between 1966 and 2000. Error bars represent 1 standard error.

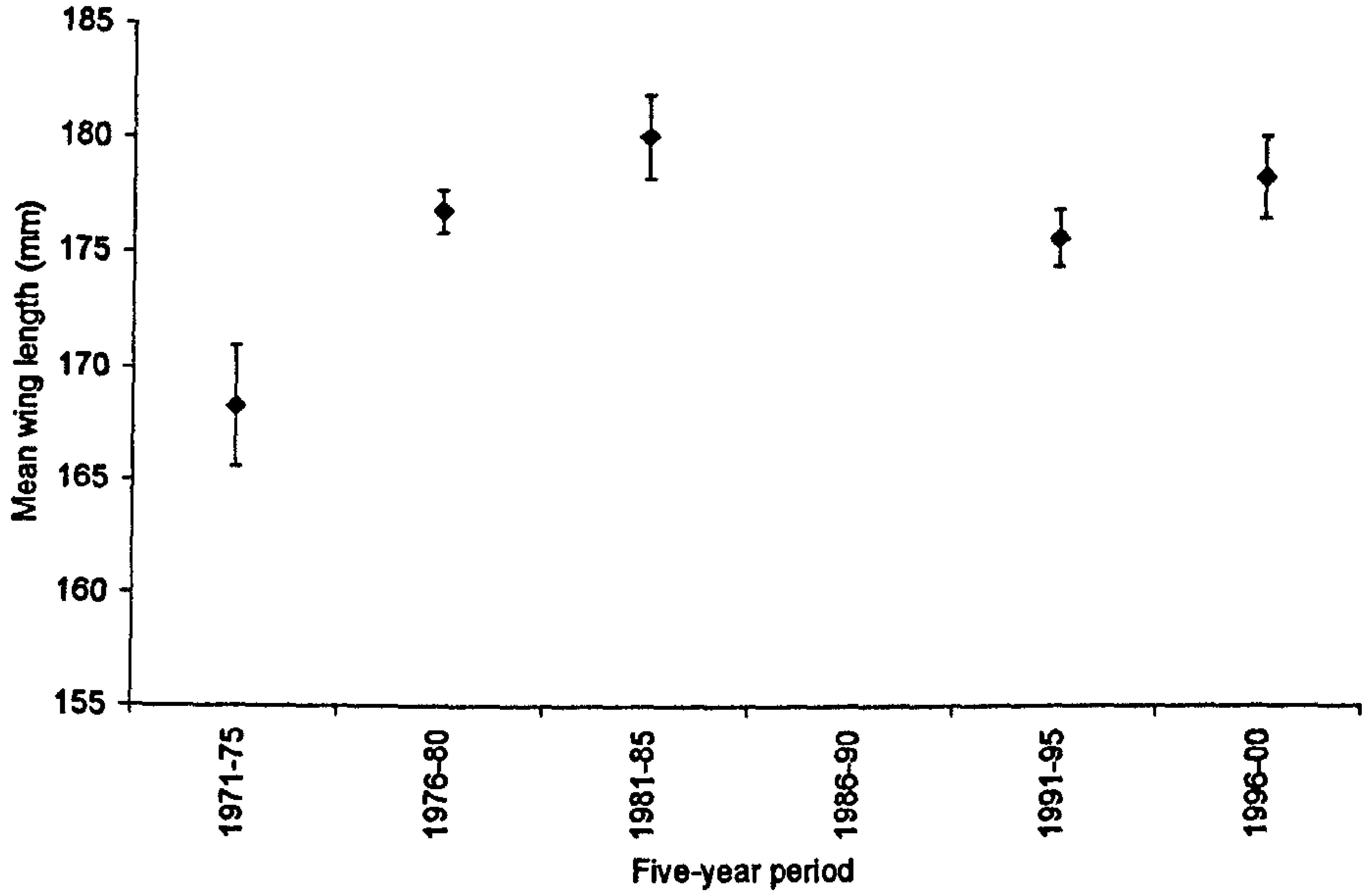


Figure 11.2 Mean adult Turtle Dove wing length in summer for each five-year period between 1971 and 2000. Error bars represent 1 standard error.

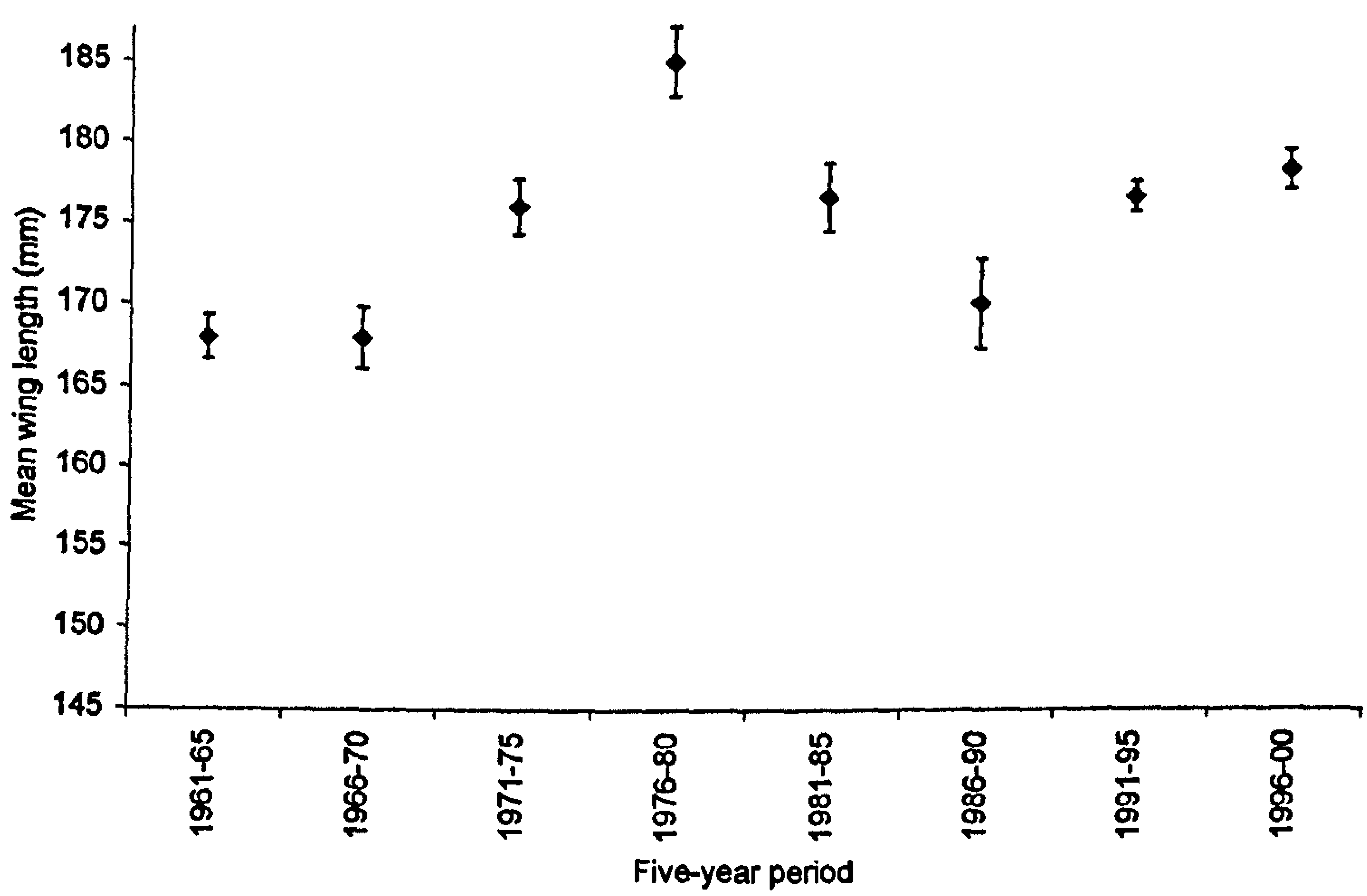


Figure 11.3 Mean adult Turtle Dove wing length in autumn for each five-year period between 1961 and 2000. Error bars represent 1 standard error.

11.3.2 Body weight

During the period 1960-2000 the mean body weight of Turtle Doves was 154.4 ± 0.8 g (range 101-215 g; n=461). There was no significant difference between the mean weight of adults (155.0 ± 0.8 g, range 103–215 g, n=371) or juveniles (151.9 ± 2.2 g, range 101-196 g, n=90) (t_{459}=3.01, P = 0.126). The mean weight of male Turtle Doves was 158.8 ± 1.3 g (range 121-196 g, n=119), which was significantly heavier than females (155.3 ± 1.1 g, range 121–183 g, n=124; t_{241} = -2.07, P = 0.039). There was a significant interaction between age and five year period when investigating their effect on weight (2-Way ANOVA, $F_{8,451}$=3.47, P = 0.001). When time (year) was entered as a linear variable there was a significant interaction between age and year ($F_{1,459}$=4.52, P = 0.034).

There was no significant effect of sex on weight (log transformed) when entered into an ANCOVA with wing length (log transformed) as covariate ($F_{1,238}$=0.01, P = 0.975). It was therefore appropriate to remove the sex factor from the analysis as it was controlled for by wing length (males tended to be longer winged). Turtle dove body weight did not vary significantly with year (t_{452}=0.18, P = 0.856) when controlling for the effect of body size (log(wing length).

There was no significant trend in spring, summer or autumn mean body weight during the period 1960-2000 (Table 11.1; Figures 11.4 to 11.6).

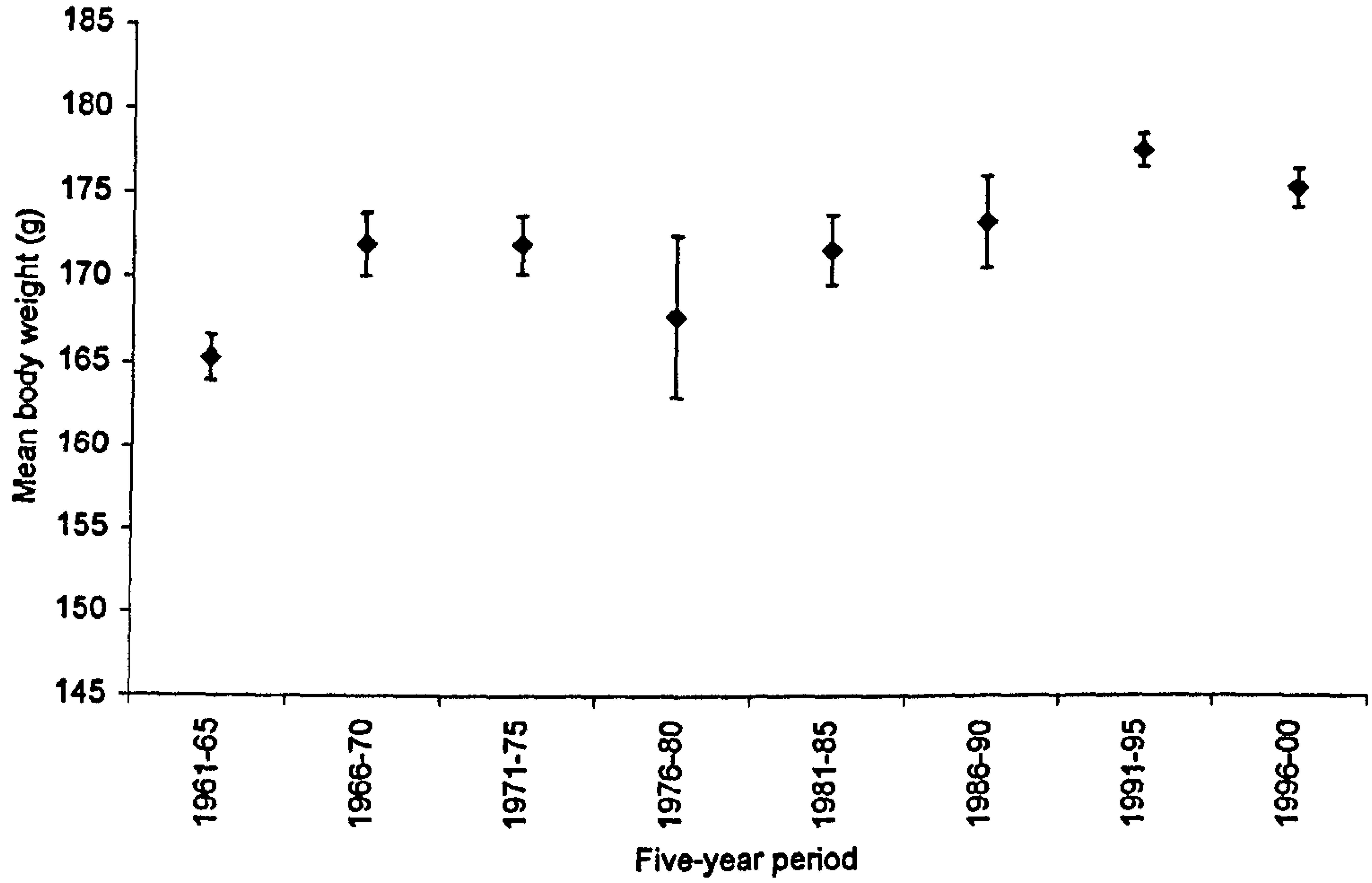


Figure 11.4 Mean Turtle Dove body weight in spring for each five-year period between 1966 and 2000. Error bars represent 1 standard error.

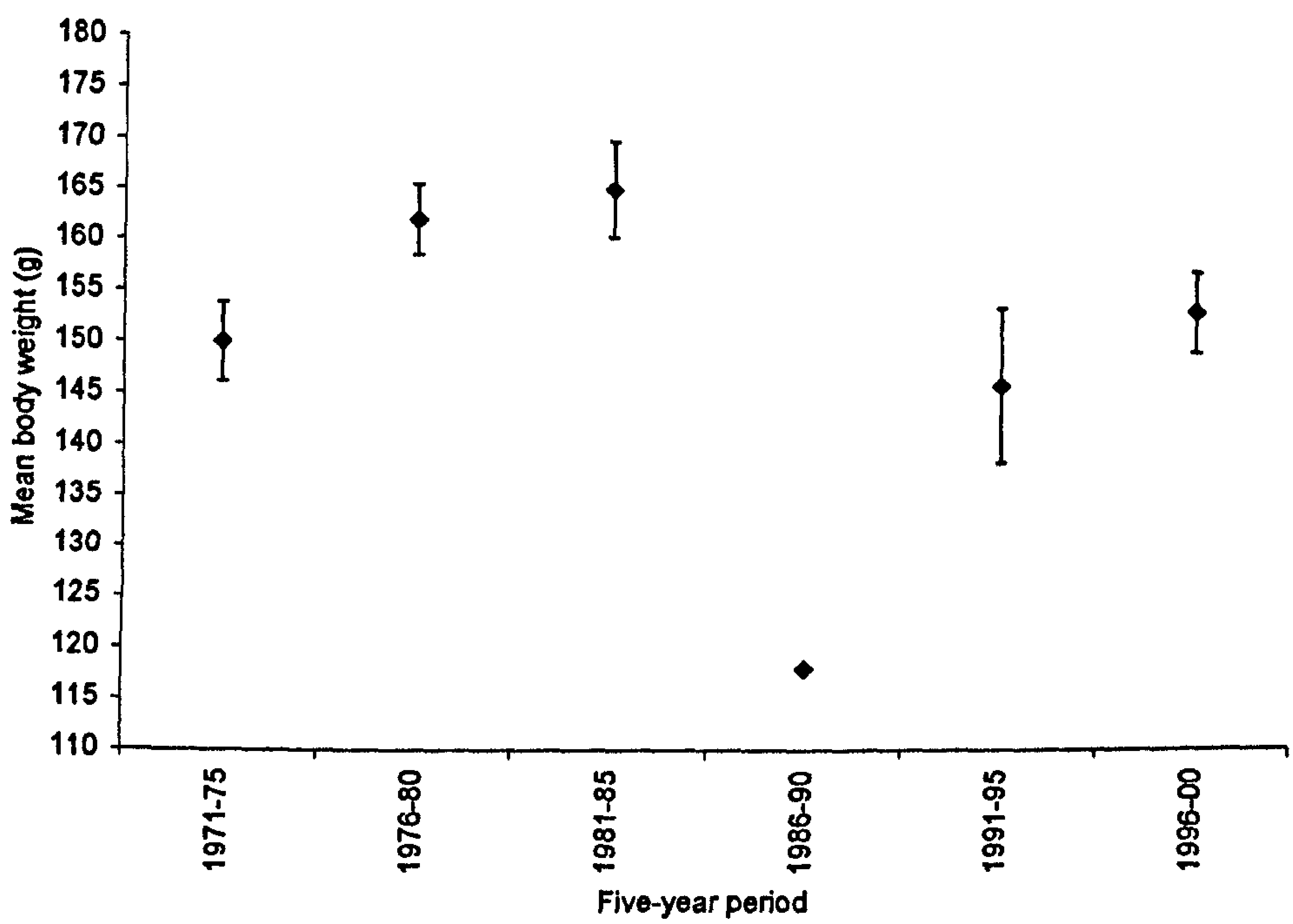


Figure 11.5 Mean Turtle Dove body weight in summer for each five-year period between 1971 and 2000. Error bars represent 1 standard error.

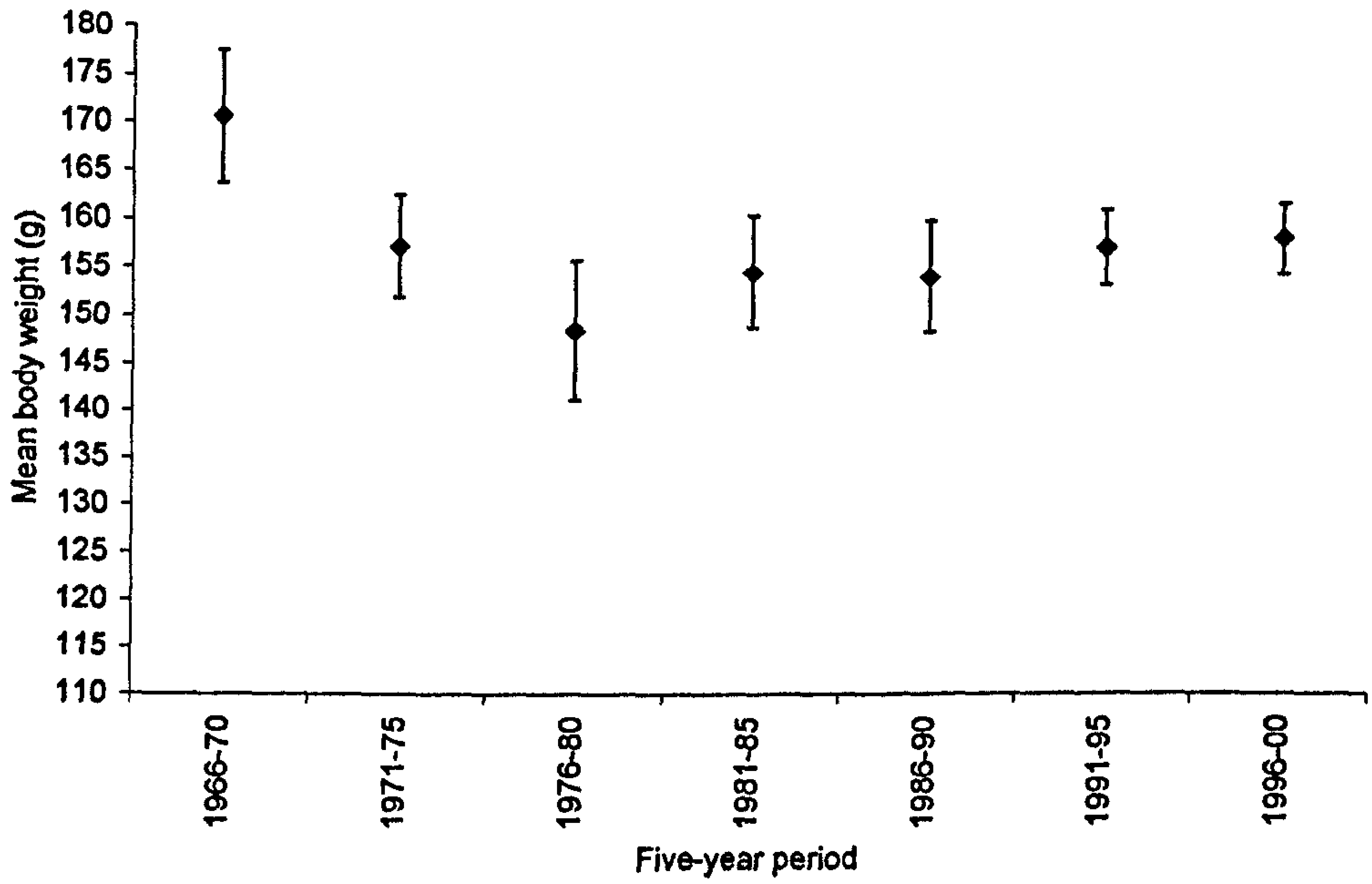


Figure 11.6 Mean Turtle Dove body weight in autumn for each five-year period between 1966 and 2000. Error bars represent 1 standard error.

11.4 Discussion

In total, approximately 4500 Turtle Doves have been caught and ringed in Britain and Ireland between 1960 and 1998 (Clark, *et al.* 2000). Unfortunately our appeal to current members of the ringing scheme, the Bird Observatories and the BTO yielded biometric data from only 480 Turtle Doves. Most of these data (over 50%) were collected during the period 1995-2000, so when the dataset was grouped by time period, bird age or sex the resulting data were sparse and this may have produced some spurious results.

The difference between adult and juvenile wing length is probably due to incomplete growth of the flight feathers of recently fledged nestlings. It is difficult to explain the reason for the observed increased in the wing length of birds caught during spring. The implication is that the population of turtle doves breeding in Britain has increased in body size. However, this is only supported by an increase in turtle dove body weight during spring. It is therefore possible that the results obtained here are spurious owing to small sample sizes.

There was no evidence of a decline in body weight of Turtle Doves caught between 1960 and 2000 in Britain. There was thus no independent confirmation of the hypothesis put forward by Chapter 3 that lower breeding performance of Turtle Doves is due to poorer body condition. However, the results do not allow rejection of this hypothesis either, so it remains unproven one way or the other.

CHAPTER 12

CONCLUSIONS AND CONSERVATION RECOMMENDATIONS

In this chapter the results of this study are discussed in the context of the decline of the Turtle Dove in Britain. These conclusions are discussed in relation to the findings of other autecological studies of farmland birds. Recommendations then follow, for management that will facilitate population recovery of Turtle Doves in Britain, and for further research that will add to our understanding of the species.

12.1 Causes of the Turtle Dove decline

12.1.1 Breeding biology

The territory distribution of Turtle Doves appears to be linked to the availability of suitable nesting habitat, primarily bushes and trees within scrub, hedges, coniferous plantations and woodland edge. Unmanaged, overgrown bushes, typically with climbers, were used for nesting. Hedgerow and scrub removal has historically been a feature of agricultural intensification (Pollard *et al.* 1974, Barr *et al.* 1993). Today, remaining hedges are often intensively managed, receiving in most cases an annual cut (McDonald & Johnson 1995). These two actions have reduced the quantity and quality of nesting habitat available for Turtle Doves.

The length of the Turtle Dove's breeding season in Britain is now shorter and birds appear to finish breeding earlier. In the 1960s, 24% of nesting attempts were started in August compared with only 5% during this study. Based on this alone, the number of nesting attempts now would be expected to be 20% lower than in the 1960s $(1-((1-0.24)/(1-0.05)) = 0.20)$. The reduction in the length of the breeding season is supported at the national scale, as there has been a shift in the timing of autumn migration, which is now significantly earlier. The observed reduction in the number of clutches each pair lays is in fact 45%, having fallen from 2.9 ± 0.1 in the 1960s to 1.6 ± 0.1 in the 1990s. Consequently, the number of young that successfully fledge has dropped from 2.1 ± 0.3 in the 1960s to 1.3 ± 0.2 in the 1990s. All else being equal, the prediction is that this reduced breeding output would lead to approximately a 17% annual decrease in the British breeding population of Turtle Doves if replicated throughout the British breeding range. Such a decline was not apparent at the two main study sites during the three years of this study, suggesting either that survival has improved since the 1960s, or that immigration into our study areas has compensated for the poor productivity. The ultimate cause of the reduction in breeding output is not known, but it is possible that changes in the spatial and temporal availability of food and the associated change in diet (see later), may be affecting adult body condition. Birds may be experiencing problems attaining and maintaining suitable body condition throughout the breeding season and may therefore finish breeding earlier.

12.1.2 Foraging behaviour and diet

Turtle doves occupy relatively large home ranges that on average are between 83 and 497 ha in size. Foraging distances for the species are also large, being on average between 0.5 to 1.5 km in length and up to a maximum of 10 km. The main cause seems to be the distance between nesting habitats and suitable feeding areas.

Turtle doves today make little use of natural feeding sites compared to the 1960s, and are much more dependent on food provided by man, for example spilt and stored grain and animal feed. The results from the experimental work suggest, however, that at the local scale food provided by man does not appear to improve breeding densities or success.

Turtle doves formerly made extensive use of "natural" feeding sites in relatively large numbers when such sites were available. Many of the feeding habitats used in the 1960s, including hay fields, clover leys, stooked wheat and weed-rich fields no longer exist or have been greatly altered through agricultural intensification. This has undoubtedly altered food availability in terms of both its abundance and distribution through the breeding season.

The shift in foraging behaviour is reflected in the diet, which has changed from being predominately based on weed seeds to being dominated by cultivated seeds (mainly wheat and oilseed rape). Although it appears that diet does not have a direct effect on breeding success, it is considered likely that all factors combined have had a detrimental synergistic impact on the species.

It is possible to postulate that:

(a) Food availability early in the breeding season is restricted, both in abundance and distribution. This probably prevents birds attaining or maintaining suitable body condition after migration and during the breeding season.

(b) The relatively large distance between nesting and feeding sites causes adults to forage over large distances so that body condition may be hard to maintain.

However, this hypothesis remains unproven one way or the other.

12.2 Conclusions of other studies of farmland birds.

In recent years a number of autecological studies of farmland birds have been carried out. A diverse range of species have been studied, including Grey Partridge (Potts 1986), Skylark (Donald & Vickery 2000, Donald *et al.* 2001), Song Thrush (Thomson & Cotton 2000), Linnet (Moorcroft & Wilson 2000), Yellowhammer (Bradbury & Stoate 2000) and Corn Bunting (Brickle & Harper 2000). Ongoing studies include Lapwing (RSPB/Harper Adams College), Swallow (RSPB/Oxford University), Tree Sparrow (RSPB), Bullfinch (RSPB/Oxford University), House

Sparrow (RSPB/Oxford University)) and Reed Bunting (RSPB). Additionally studies of rare and endangered species have also been undertaken, including Corncrake (e.g. Green & Stowe 1993), Stone Curlew (e.g. Green *et al.* 2000), Red-backed Shrike (Vanhinsbergh 2000) and Cirl Bunting (e.g. Evans 1997a).

In all of these studies the two principal causes of population declines have been the loss of suitable nesting habitat and a reduction in food availability during the breeding season and over winter. Other causes include the increased loss of nests through mechanisation and predation, and the loss of mixed farming. In two of the species (Song Thrush (Thomson & Cotton 2000) & Linnet (Moorecroft & Wilson 2000)) a reduction in the number of nesting attempts undertaken per individual female per year, and increase post-fledging survival have been implicated.

Loss of nesting habitat.

The loss of suitable nesting habitat at the national scale has reduced the population size of Stone Curlews (Green and Griffiths 1994), which were once dependent on grazed semi-natural grasslands. The other main nesting habitats are hedgerows and the hedge bottom/field margin, which have both reduced in availability and structure over the last 40 years (Pollard *et al.* 1974, Barr *et al.* 1993). The loss and degradation of hedges and field margins have affected Grey Partridge (Rands 1986), Red-backed Shrikes (Vanhinsbergh 2000) and Yellowhammers (Bradbury & Stoate 2000). The switch from spring sown to autumn sown cereals has reduced nesting habitat for Stone Curlews (Green *et al.* 2000), Lapwing (Wilson *et al.* 2001) and

Skylarks (Donald & Vickery 2000) as these species avoid nesting in tall vegetation. The absence of clumps taller vegetation within hay fields and the switch from hay to silage has reduced nests sites for Corncrake (Green 1995, 1996).

Reduced food availability

Reduced food availability has been shown to affect birds during the breeding season and over winter. The young of most farmland bird species feed on insects during, at least, the first two weeks after hatching. The increased use of pesticides has been linked directly to reductions in invertebrate numbers or indirectly by reducing the abundance of invertebrate host plants (Campbell *et al.* 1997, Sotherton & Self 2000). This reduction in invertebrates has been linked to reduced chick survival and ultimately population declines in Grey Partridge (Potts 1986), Skylark (Donald & Vickery 2000), Red-backed Shrike (Vanhinsbergh), Yellowhammer (Bradbury & Stoate 2000) and Corn Bunting (Brickle and Harper 2000). The degradation of hedge bottoms, field margins and the intensive management of grasslands are also thought to have reduced invertebrates available to feeding Yellowhammers (Bradbury & Wilson 2000). The use of herbicides and the consequent reduction in arable weed seeds was thought to have reduced food availability for Linnet chicks during the 1970s & 1980s (Moorecroft & Wilson 2000)

The switch from spring to autumn sown crops and the increased use of herbicides have reduced that amount and quality of over-wintered stubbles. Stubbles are the principal habitat used by Skylarks (Donald *et al.* 2001) Cirl Buntings (Evans & Smith

1994) and Corn Buntings (Donald and Evans 1994) during the winter and the loss of this habitat has contributed to Skylarks (Donald & Vickery 2000), Yellowhammer (Bradbury & Wilson 2000) and Cirl Buntings (Evans *et al.* 1997). The loss of mixed framing is also thought to have contributed to the decline of the Red-backed Shrike (Vanhinsbergh 2000) and Cirl Bunting (Evans 1997b).

Nest loss

Nest losses through predation and mechanisation primarily affects ground-nesting species. Increased predation has contributed to the decline of the Grey Partridge (Potts 1986, Tapper *et al.* 1996) and Stone Curlew (Bealey *et al.* 1999). It is thought that increased begging calls of starving chicks has increased predation in the Skylark (Donald & Vickery 2000), Cirl Bunting (Evans *et al.* 1997) and the Corn Bunting (Brickle & Harper 2000). The increased use of mechanisation, the earlier harvesting of crops, brought about by the switch from spring to autumn sown crops and a switch from hay to silage, and the use of arable fields in place of natural habitats has increased nest and chick losses in Corncrake (Green 1995, Green *et al.* 1997, Tyler *et al.* 1998), Stone Curlew (Green *et al.* 2000) and Corn Bunting (Brickle & Harper 2000).

Common factors causing Turtle Dove and farmland bird declines.

The results from the studies highlighted above (see above for references) show a number of features in common with the findings presented in this thesis. The loss of nesting habitat, primarily hedges and scrub, is thought to restrict the territory distribution of the Grey Partridge, Turtle Dove, Red-backed Shrike and Yellowhammer. The reduction in breeding performance, brought about by a reduction in the number of nesting attempts undertaken per pair, has been shown to have consequences for population size in the Turtle Dove, Song Thrush and Linnet. The reduction in food availability attributable either directly or indirectly to pesticide use has been shown to affect the Grey Partridge, Turtle Dove, Skylark, Red-backed Shrike, Yellowhammer and Corn Bunting. These findings make it difficult to separate the declines experienced by Turtle Doves and many other farmland bird species, and changes in land management associated with recent agricultural intensification.

12.3 Recommendations for conservation action

The Turtle Dove UK Species Action Plan (Anon 1998) has the following objectives and targets:

1. "In the short term, halt or reverse the decline in numbers of the Turtle Dove by the year 2003 so that the Breeding Bird Survey index is at least at 1996 levels".
2. "In the long term, see a sustained recovery in numbers so that the BBS index is at least 50% higher than 1996 levels by 2008".

The following recommendations for conservation action arising from this study will help deliver these targets. Although tailored towards Turtle Doves, if implemented these recommendations are likely also to help other wildlife dependent on the agricultural environment.

12.3.1 Management options

Nesting habitat

The aim here is to reverse the historical reduction in Turtle Dove nesting habitat by recreating suitable hedgerows and patches of woodland or scrub, as follows:

(a) Neglected hedgerows should be restored, or new hedgerows planted with thorny bushes, particularly Hawthorn, interspersed with Elder. Climbers such as Traveller's Joy, bramble and honeysuckle should be encouraged or planted so that they ramble through and over the bushes. The bushes should be allowed to reach a minimum height of 4.5 m and a width of 3 m. Hedges should be cut once every two-three years, if possible on alternate sides.

(b) Stand-alone areas of scrub and scrubby margins to woodland blocks should be retained. The margins of new and existing stands of broad-leaved trees should be planted with thorny bushes, particularly Hawthorn, interspersed with Elder and climbers. New stands of trees should be located near foraging habitats on farmland.

(c) Small coniferous plantations could be planted as an alternative (or in addition) to scrub, and should be allowed to grow to at least 4.5 m to be attractive to Turtle Doves - approximately 10 years. The doves tended to nest near the edge of the plantations, so the plantations need not be wider than 10 m. Turtle doves in this study used Norway Spruce, but most commercially grown coniferous trees are likely to be suitable. Climbers should be planted or encouraged.

Food availability

The aim is to counteract the shrinking availability of natural food resources by encouraging patches of arable plants whose seeds are eaten by Turtle Doves and by providing alternative sources of seed, as follows:

(d) Weed-rich areas, with low open vegetation cover, should be allowed to develop within or adjacent to cropped fields. The areas should preferably be tilled annually each autumn and receive no herbicides other than ones targeted specifically at pernicious agricultural weeds (e.g. Black Grass, Creeping Thistle). Alternatively, or in addition, it is possible to establish such areas by sowing seed mixes that contain species favoured by Turtle Doves, for example Field Pansy, Common Fumitory, Knotgrass and Redshank.

(e) Existing herb-rich grassland should be protected and managed for a late hay crop (cut after 15 July) at least every three years to allow seed production, and grazed short in the other years. On light soils, the creation of such grassland should be encouraged by de-intensifying the use of improved grassland or by arable reversion using mixtures of non-competitive grasses such as fescues and seed-bearing herbs.

(f) Patches of unharvested cereal or rape should be left overwinter until at least the end of May, when, having collapsed, they should provide a source of residual seed for newly arrived migrant Turtle Doves.

(g) Post-harvest cereal, rape and pea stubbles should be left until at least the end of August to allow good feeding for Turtle Doves prior to migration.

(h) Supplementary food may be provided in the form of waste grain or tailings, preferably placed close to suitable nesting habitat, in places where rat infestation is not likely to cause a problem.

12.3.2 Policy options

Current policy

Within the current policy framework it is possible to incorporate many of the conservation management recommendations for Turtle Doves within modern agricultural systems, often with a financial incentive attached. I review below the principal schemes facilitating such payments in England, and highlight the relevant options as appropriate. To deliver widespread benefits for the Turtle Dove (and many other species), sufficient money must be made available by government to encourage their uptake by as many farmers as possible within its breeding range.

Set-aside (Arable Area Payment Scheme)

Two types of green cover are suitable for increasing food availability, natural regeneration and wild bird cover. Natural regeneration corresponds to management option (d) above. Wild bird cover provides a means of implementing (f), provided that the unharvestable mixture includes cereals or rape as one of its components and is left for more than a year. In both types of cover, the natural weed flora could be enhanced by sowing additional plants whose seeds are eaten by Turtle Doves.

Environmentally Sensitive Areas (ESAs)

Prescriptions targeted at the maintenance or creation of chalk grassland, old meadows and herb-rich pastures may provide suitable feeding habitat for Turtle Doves if they result in a herb-rich sward that is allowed to set seed at regular intervals, but grazed short otherwise (management option (e) above) – this applies to most lowland ESAs. The prescriptions for uncropped wildlife strips (Breckland) could produce suitable weed-rich areas (d). The provision of overwinter stubbles (Breckland, Cotswold Hills, South Downs, West Penwith) could increase pre-migration food availability (g). Hedgerow restoration (Blackdown Hills, Cotswold Hills, Shropshire Hills, Suffolk River Valleys, Upper Thames Tributaries) could help to provide nesting habitat especially if climbers are included (a). However, scrub removal (South Downs, South Wessex Downs) would have the opposite effect (b).

Countryside Stewardship

Annual prescriptions for managing herb-rich grassland and hay meadows are appropriate for management option (e) above, as is the one for recreating grassland on cultivated land. Annual prescriptions for managing 6-m arable field margins may be suitable for (d) as long as they are cultivated in the autumn to prevent dense vegetation developing; the natural seed flora could be enhanced by sowing additional plants whose seeds are eaten by Turtle Doves. One-off payments are also available for hedgerow restoration, which could help provide nesting habitat especially if climbers are included (a).

Arable Stewardship (pilot)

In 1998, Arable Stewardship was introduced as a pilot scheme in two areas of England, and discussions are under way to extend it nationally within Countryside Stewardship. Under the pilot scheme, prescriptions for overwintered stubbles followed by a spring/summer fallow, uncropped wildlife strips and wildlife seed mixtures could produce suitable weed-rich areas (management option (d) above), as could conservation headlands with no fertiliser applications if sufficiently open. Wildlife seed mixtures could also satisfy (f) if the mixture includes cereals or rape and is left for more than a year. In all these cases, the natural weed flora could be enhanced by sowing additional plants whose seeds are eaten by Turtle Doves. The grass ley resulting from an undersown spring cereal could be attractive if used for hay production or grazed lighly enough to allow seed set (e). The prescriptions for overwintered stubbles could increase pre-migration food availability (g), especially if preceded by limited herbicide use on the crop.

Woodland Grant Scheme / Farm Woodland Premium Scheme

The grants could help in the establishment of small areas of coniferous woodland suitable as nesting habitat in the medium term (management option (c)) and the establishment of scrubby margins (b). The minimum area requirement is for 1 ha in total, which may be made up of several smaller and separate woodland blocks.

Landfill Tax Credits Scheme

This scheme may offer an opportunity to grant-aid the provision of supplementary food (management option (h)).

Future policy

Future agricultural policy should encourage farmers to manage land in a more environmentally friendly fashion. Ongoing reform of the European Union's Common Agricultural Policy is scheduled for 2006. This provides the opportunity for introducing compulsory cross-compliance, whereby a farmer would receive agricultural subsidy (e.g. Arable Area Payments) conditional on compliance with environmental standards (payments may be reduced or cancelled if a farmer does not comply with these standards). If introduced, the benefits should include the provision of nesting and feeding habitats for the Turtle Dove.

Future policy also needs to address the areas which are currently not adequately covered by existing policy, these include, (i) the wide-spread management of arable field margins, (ii) the re-establishment of arable fields in pasture dominated areas, (iii) the planting and management of scrub, (iv) the provision of supplementary food.

Organic farming

Many investigations have shown that the floral diversity of organically farmed arable fields and grassland tends to be higher than that of conventionally farmed land. However, economic pressures and improvements in mechanical weed control mean that the preservation and development of a diverse weed flora cannot be taken for granted under an organic farming regime (van Elsen 2000). Organic farming *per se* cannot therefore be seen as a means of aiding Turtle Dove recovery, but, like conventional farming, needs to adopt the management options outlined above.

Advice

It is vital that advice given to farmers and land managers be as accurate and up-to-date as possible. This study has resulted in recommendations that should be summarised in an advisory leaflet, with the twofold aim of raising awareness of the problems and offering practical management solutions to farmers and land managers throughout the Turtle Dove's British breeding range.

12.4 Summary of conclusions and conservation recommendations

ECOLOGICAL STAGES	FACTORS	MANAGEMENT MEASURES
Nesting habitat	- Reduced availability - Inappropriate management	- Plant new hedges, scrub and woodlands containing thorny bushes and climbers - Restore old hedges - Manage to allow hedges to reach 4.5 m height and 3 m width. Cut hedges as infrequently as possible, at most every other year and on alternate sides de appropriate advice
Diet	- Changed foraging behaviour - Reduced food availability - Change in diet	- Provide suitable feeding habitats near suitable nesting habitats - Provide supplementary food - Establish and manage feeding habitats that are weed-rich yet open by tilling and sowing - Encourage seed production within herb-rich grassland - Leave patches of unharvested cereal or rape until end May at least
Breeding	- Shorter season - Reduced productivity Possibly reduced food availability and longer foraging distances affecting adult condition.	See above

12.5 Recommendations for future work

Continuation of annual monitoring

Within Britain, annual monitoring of population size through the BTO Breeding Bird Survey and breeding success through the BTO Nest Record Scheme should continue. Regular assessments of population distribution need to be repeated through atlas surveys, carried out approximately every 20 years. Ideally these would be extended to cover the species' entire breeding range in Europe. The ringing and co-ordination of ringing data of the Turtle Dove needs to be encouraged within the UK and across Europe.

Effect of diet on body condition

The importance of diet in maintaining adult body condition and improving breeding success could be assessed through feeding trials involving captive birds. The trials would involve feeding different groups of birds with varying amounts of weed and cultivated seeds, and measuring the effect on body condition and breeding success. The nutritional value of various seeds could be assessed through laboratory analysis and trials with captive birds could investigate seed selection.

Efficacy of management recommendations

It would be advisable to test the effectiveness of the recommendations made to assist the recovery of Britain's Turtle Doves, through field trials carried out at an appropriate scale. The suitability of the recommendations could be investigated in two ways. Firstly, by carrying out the management, then monitoring to see if Turtle Doves make use of the managed habitats for nesting or feeding. Secondly, by monitoring the local breeding birds and seeing how they respond in terms of increased territory density, reduced foraging distance and increased productivity.

Studies outside Britain - migration and wintering areas

The precise impact that hunting in southern Europe has on the population dynamics of the Turtle Dove is not fully known. Better monitoring and co-ordination of data is required to provide information on the numbers killed, their age structure and the timing of harvesting.

Very little detailed ecological research has been undertaken on the Turtle Dove in its wintering areas. Indeed, the precise wintering locations of Turtle Doves breeding in Britain is unknown. Studies are needed to investigate the species' over-wintering habitat and feeding requirements and to measure the impact of habitat change, agricultural development and climate change.

Comparative ecological study

A number of doves from the genus *Streptopelia* are present within the range of the Turtle Dove, in particular the Collared Dove within the Turtle Dove's breeding range and the Laughing Dove on the wintering grounds. Both these species appear to have similar ecologies to the Turtle Dove, but have not experienced the same declines in abundance and distribution. A study that investigates the reasons for these doves' continued success may provide further insights into reasons for the Turtle Dove's decline. The North African race of Turtle Doves *S. t. arenicola* is reportedly so abundant in Morocco that it is considered a pest. Here too, a comparative ecological study may shed light on why the status of *S. t. turtur* is so markedly different.

Common and scientific names for birds mentioned in the text. Species are arranged in alphabetic order based on the common name.

Common name	Scientific name
Anna's Hummingbird	*Calypte anna*
Arctic Skua	*Stercorarius parasiticus*
Barn Owl	*Tyto alba*
Blackbird	*Turdus merula*
Bullfinch	*Pyrrhula pyrrhula*
Chaffinch	*Fringilla coelebs*
Cirl Bunting	*Emberiza cirlus*
Crested Tit	*Parus cristatus*
Collared Dove	*Streptopelia decaocto*
Corn Bunting	*Miliaria calandra*
Corncrake	*Crex crex*
Dunnock	*Prunella modularis*
Goldfinch	*Carduelis spinus*
Great Bustard	*Otis tarda*
Great Tit	*Parus major*
Greenfinch	*Carduelis chloris*
Grey Partridge	*Perdix perdix*
Hobby	*Falco subbuteo*
House Martin	*Delichon urbica*
House Sparrow	*Passer domesticus*
Jay	*Garrulus glandarius*
Kestrel	*Falco tinnunculus*
Lapwing	*Vanellus vanellus*
Laughing Dove	*Streptopelia senegalensis*
Linnet	*Carduelis flavirostris*
Little Owl	*Athene noctua*
Magpie	*Pica pica*
Meadow Pipit	*Anthus pratensis*
Mistle Thrush	*Turdus viscivorus*
Pheasant	*Phasianus colchicus*
Pied Wagtail	*Motacilla alba*
Quail	*Cotrnix coturnix*
Red-backed Shrike	*Lanius collurio*
Red-legged Partridge	*Alectoris rufa*
Reed Bunting	*Emberiza schoeniclus*
Robin	*Erithacus rubecula*
Rough-legged Buzzard	*Buteo lagopus*
Sand Martin	*Riparia riparia*
Shag	*Phalacrocorax aristotelis*
Skylark	*Aluada arvensis*

Common name	**Scientific name**
Song Sparrow	*Melospiza melodia*
Song Thrush	*Turdus philomelos*
Sparrowhawk	*Accipiter nisus*
Spotted Flycatcher	Muscicapa striata
Starling	Sturnus vulgaris
Stock Dove	Columba oenas
Stone Curlew	Burhinus oedicnemus
Swallow	Hirundo rustica
Tree Sparrow	Passer montanus
Turtle Dove	Streptopelia turtur
Willow Tit	Parus montanus
Woodpigeon	Columba palimbus
Wren	Troglodytes troglodytes
Wryneck	Jynx torquilla
Yellow Wagtail	Motacilla flava
Yellowhammer	Emberiza citrinella

Common and scientific names for plants mentioned in the text. Species are arranged in alphabetic order based on the common name.

Common name	Scientific name
Alder	*Alnus glutinosa*
Apple	*Malus domestica*
Black Bindweed	*Fallopia convolvulus*
Black Grass	*Alopecurus myosuroides*
Blackthorn	*Prunus spinosa*
Bramble	*Rubus fruticosus*
Broad-leaved Dock	*Rumex obustifolius*
Charlock	*Sinapis arvensis*
Common Chickweed	*Stellaria media*
Common Cleavers	*Galium aparine*
Common Field Speedwell	*Veronica scutellata*
Common fumitory	*Fumaria officinalis*
Common Mallow	*Malva parviflora*
Common Nettle	*Urtica dioica*
Common Orache	*Atriplex patula*
Common Poppy	*Papaver rhoeas*
Common Ragwort	*Senecio jacobaea*
Corn Cockle	*Agrostemma githago*
Cornflower	*Centaurea montana*
Cow Parsley	*Anthriscus sylvestris*
Creeping Buttercup	*Ranunculus repens*
Creeping Thistle	*Cirsium arvense*
Daisy	*Bellis perennis*
Dandelion	*Taraxacum* Sect. *Ruderalia*
Dog Rose	*Rosa canina*
Dovesfoot Cranesbill	*Geranium molle*
Elder	*Sambucus nigra*
Fat hen	*Chenopodium album*
Field pansy	*Viola arvensis*
Fig-leaved goosefoot	*Chenopodium ficifolium*
Ground ivy	*Glechoma hederacea*
Groundsel	*Senecio vulgaris*
Guelder Rose	*Viburnum opulus*
Hawthorn	*Crataegus monogyna*
Hazel	*Corylus avellana*
Hedge Mustard	*Sisymbrium officinale*
Hogweed	*Heracleum sphondylium*
Holly	*Ilex aquifolium*
Honeysuckle	*Lonicera periclymenum*
Knotgrass	*Polygonum aviculare*
Lilac	*Syringa vulgaris*

Common name	**Scientific name**
Norway Spruce	*Picea abies*
Redshank	*Persicaria maculosa*
Ribwort Plantain	*Plantago lanceolata*
Rosebay Willowherb	*Chamerion angustifolium*
Scentless Mayweed	*Tripleurospermun inodorum*
Shepherd's Purse	*Capsella bursa-pastoris*
Snowberry	*Symphoricarpos albus*
Swinecress	*Coronopus squamatus*
Traveller's Joy	*Clematis vitalba*
Umbelliferae	
White Campion	*Silene latifolia*
White Clover	*Trifolium repens*
White Poplar	*Populus alba*
Wild Mignonette	*Reseda lutea*
Willow sp.	*Salicaceae*
Yarrow	*Achillea millefolium*

Common and scientific names for mammals mentioned in the text. Species are arranged in alphabetic order based on the common name.

Common name	**Scientific name**
European Rabbit	*Oryctolagus cuniculus*

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